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HANDBOOK OF HYGIENE

AND

SANITARY SCIENCE

By the same Author.

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A

HANDBOOK OF HYGIENE

AND

SANITARY SCIENCE

BY

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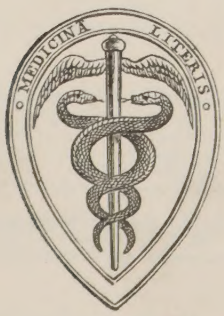
SIXTH EDITION



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PREFACE TO THE SIXTH EDITION

THE last edition of this Handbook has been out of print for several months, and I very much regret the unavoidable delay which has occurred in the preparation of the present edition. No efforts, however, have been spared to render the work still more worthy of the very favourable reception which has been accorded to it ever since it was first published. Although much new matter has been added, and the whole carefully revised and brought up to date, the size of the volume has been kept within the limits of the previous edition, by omitting much which in a sense had become obsolete, and by curtailing the later as well as the more recent typical reports on outbreaks of fever and infectious disease which are given as illustrations.

Among the additions and interpolations which have been made, I may mention the following:—In the section on the Examination of Food, besides introducing other useful information, I have given a brief description of the several diseases which render the flesh of animals unfit

for the food of man. The chapter on Water Analysis has also been extended so as to render it practically complete for ordinary sanitary purposes, and a short section has been appended on the analysis of Sewage and Effluents. A new chapter has been written on Soils and Localities, and their Influence on Health; while the chapter on Infectious Diseases has been remodelled so as to give the mere salient points in diagnosis, period of incubation, mode of propagation, and prevention. In order to embrace the results of recent researches, and more particularly the extended inquiry conducted by Dr. Parsons of the Local Government Board on Disinfection by Heat, a separate chapter has been devoted to Disinfectants and Disinfection. The chapter on Vital Statistics has been carefully revised so as to embrace recent statistical data, and in the concluding chapter the digest of the Sanitary Acts applying more particularly to the duties of Medical Officers of Health has been brought up to date. Lastly, the Appendix has been greatly curtailed by excluding statistical tables on the classification of disease, and in other respects it has been rearranged and supplemented by additional information, which will, it is hoped, render it still more useful.

I have again to express my great obligations to Dr. Buchanan, F.R.S., Medical Officer of the Local Government Board, for kindly favouring me with copies of official

memoranda issued by the department, and the more recent reports of the Medical Inspectors of the Board. I am also greatly indebted to the *Sanitary Record* and other periodicals and publications for much valuable information, of which due acknowledgment is given in the text.

As in the last two editions, I have omitted the consideration of several subjects which appertain rather to the domain of Domestic Hygiene; but these I have endeavoured to treat more fully in the small supplementary work entitled *Healthy Life and Healthy Dwellings*.

23 Claremont Road, Leamington.
August 1886.

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PUBLIC HEALTH AND PREVENTABLE DISEASE

PUBLIC HYGIENE may be defined as that branch of sanitary science which concerns the physical condition of communities. It embraces a consideration of the various influences operating upon society, whether for its material good or its actual deterioration, with the view of extending the former, and preventing, or ameliorating, as far as possible, the effects of the latter. It involves the enactment of laws by which the safety of the whole may be protected against the errors of a part, and, above all, it aims at the prevention of disease by the removal of its avoidable causes. In a wide sense, therefore, the science of public hygiene enlists the services of the people themselves in continuous efforts at self-improvement; of the teachers of the people, to inculcate the best rules of life and action; of physicians in preventing as well as curing disease; and of lawgivers, to legalise and enforce measures of health-preservation. But while it is the special province of the medical profession, as guardians of the public health, to study the causes of physical deterioration and disease, and to point out how far these causes may be controlled or averted, the general well-being of the people must mainly depend on their own exertions and self-restraint. Sanitary improvements in man's material surroundings will not compensate for social transgressions against laws

of morality; for public virtue is essential to public health, and both to national prosperity.

The time, however, has gone by when people can be dragooned into cleanliness or be made virtuous by police regulations, and hence it is that the most thoughtful among practical reformers of the present day base their hopes of sanitary progress on the education of the masses as the real groundwork of national health. The people must be taught that good conduct, personal cleanliness, and the avoidance of all excesses, are the first principles of health-preservation; that mental and physical training must go hand in hand in the rearing and guidance of youth; and that morality does not consist so much in a blind observance of the formulæ of empty creeds as in a hearty submission to precepts of health. Nor is this all. They must be interested systematically in the general results of sanitary progress, and become more intimately acquainted with the social and material causes by which it is impeded. Unless a knowledge of these fundamental principles of hygiene be widely disseminated amongst them, it is in vain to expect that legislative enactments, however well devised, will succeed in raising the standard of public health to any considerable extent. But there are hopeful signs of progress even in this direction. The teaching of physiology and the laws of health, which is being gradually introduced into many schools, will doubtless be productive of much good amongst the rising generation; while the large share of attention which the discussion of sanitary questions is already receiving in the public press is the best evidence of the steady growth of intelligent conviction as regards all matters affecting the preservation of health and the prevention of disease.

Taking, then, this wide view of the scope of public hygiene, it will, I trust, prove alike interesting and useful if, by way of introduction, I give a brief historical sketch

of its various phases, and more particularly of its progress during recent years. For sanitary science, in the broad sense of the term, is knit up with the life-history of every nation, and enters largely into the history of civilisation. It figures prominently in the Mosaic code of the Jewish race, and its instructions and preventive measures, as exemplified in that code, have accounted largely for the greater comparative longevity of the Jews, for their extraordinary immunity from the recurring epidemics of the Middle Ages, and for the wide-spread, though silent influence which they have long exercised, and still exercise to the present day.

Or let us glance at those grand old Greeks who have left us such a rich store of philosophy, literature, and art. It is true that though their sanitary code, propounded by Lycurgus, was severe and cruel, yet the means which they adopted in the care and cultivation of their bodily physique, and the development of their intellectual faculties, made them the civilisers of the old world and the exemplars of modern times. But the Greeks, with all their wisdom and physical culture, knew very little of the causes of disease as it affects communities, and they accepted the terrible epidemics with which they were visited as manifestations of offended deities, or, at the best, as afflictions which could neither be avoided nor prevented. Their decline and fall as a nation were due to the luxury into which they lapsed, and the lax morality which ultimately became their ruin and opprobrium.

Referring, now, to the Romans, the other powerful nation of antiquity, we find that though they contributed but little to sanitary science, they have left some wonderful examples of sanitary engineering on a large scale. Their *Cloaca Maxima,* for example, and the aqueduct for conveying water from the hillsides, some thirty miles from Rome, to the city, were works of such stupendous magni-

tude that they have seldom been equalled or surpassed even at the present day. But the Roman Empire, like that of the Greeks, was destined to pass away, and those who have studied the social causes of its decay attribute its ultimate decline in no small degree to the epidemics which repeatedly devastated the population in the early centuries of the Christian era.

We next pass on to what have been termed the dark or Middle Ages, and to the health history of England. The accounts at first are very meagre, but when they become more numerous and reliable they tell us of frequent visitations of plague, pestilence, and famine—mixed up with stories, strange and incredible, of armies fighting in the air, showers of blood, terrible earthquakes, and the like—all of them showing how deep-rooted was the belief in the supernatural as regards epidemic disease and its causes. If, however, we look at the habits and habitations of our forefathers, we have no difficulty in accounting for the fearful mortality which prevailed amongst them. Personal cleanliness was utterly neglected. Clothing was immoderately thick and warm, and was seldom changed night or day. The diet was coarse, consisting chiefly of flesh meats highly seasoned. Strong wine or ale was drunk early in the morning, and often far into the night; in short, gluttony and intemperance were prominent characteristics of the sturdy fighting Briton of mediæval times.

Then, as regards his dwelling, we find that the towns and villages were composed for the most part of hovels, with mud walls and thatched roofs. "The floors of the houses," to quote from a well-known letter of the learned Erasmus, "were generally made with loam strewn with rushes, constantly put on fresh without removing the old, lying there in some cases for twenty years, concealing fish bones, broken victuals, and other filth," so that one can quite credit him when he says farther, "If even

twenty years ago I had entered into a chamber which had been uninhabited for some months, I was immediately seized with fever." The streets were unpaved, generally covered with clay and rushes, concealing all sorts of abominations; moreover, they were dark, narrow, and tortuous, and without sewers or drains. The rural population, on the other hand, were scattered in slight hovels over wild woods, dreary wastes, and undrained marshes, so that ague and rheumatism were always rife amongst them, and in times of scarcity, which were common enough, they were sure to suffer from famine. Add to all this, that there was constant fighting of some sort going on. Kings were warring against powerful subjects or foreign foes. Cities and towns were walled-in fortresses; and the roads were beset with marauders and highwaymen. Dogberries watched the streets but did not ward them, bravoes stabbed, burglars were plentiful, and amongst all classes life was held very cheap. Those, indeed, were days in which Mr. Darwin's doctrine of survival of the fittest was exemplified to the fullest extent; the weakly went to the wall, and left, on the whole, only those of iron constitutions to perpetuate a brave, hardy, and pushing race, which increased in numbers slowly, if at all, for centuries.

We thus see that conditions inimical to health were abundant everywhere. The walled-in cities were highly favourable to overcrowding and stagnant air; the large armies, which were in constant motion, conduced greatly to the spread of epidemic disease; while personal uncleanliness and intemperate habits made the people ready victims of disorders of all kinds. It is not surprising, therefore, that fevers and devastating epidemics were prevalent; and as instances in point, I may mention the following:—For example, in the twelfth century, there were fifteen widespread epidemics and many famines; in

the thirteenth century, twenty epidemics and nineteen famines; and in the early part of the fourteenth century there were eight epidemics and more famines. And these epidemics, it should be remembered, were not local outbreaks appearing only here and there, but they spread so far and wide that each and all of them were regarded as visitations of national disaster.

And now we come to the fatal year of 1348, when the Black Death or Great Mortality, as it was called, first appeared in England. It is believed to have been an aggravated outbreak of the Oriental Plague, which was then devastating Europe as it had devastated the East. It was an eminently contagious disease—imported, no doubt, in the first instance; but when once it gained a footing on our shores, it spread with such terrible rapidity, that within a few months almost every town and village throughout the country had been attacked, and in some places only a fourth part of the inhabitants were left alive. In London alone 100,000 fell victims to the disease, and 50,000 corpses were interred in one burial-ground, heaped together, layer upon layer, in large pits. Throughout Europe it has been estimated that twenty-five millions, or a fourth part of the entire population, were swept away. Imagination fails to realise the misery and horrors of the time. The sick died untended, charity was dead, and hope extinguished—everywhere there was terror and black despair.

Without noticing other epidemics which followed the epoch of the Black Death, the next great pestilence which ravaged the country, and known as the Sweating Sickness, broke out in 1485. Unlike the Black Death and the Oriental Plague, which reappeared in the sixteenth and seventeenth centuries, it did not originate in a foreign country to be conveyed by infection to our own shores, but it sprang into existence in this, and was no doubt

generated and propagated by the insanitary conditions of dwellings and towns, and the filthy and intemperate habits of the people. For the most part it attacked robust middle-aged adults, men fond of good living, and those amongst the poorer classes who were described as "idle persons, good ale drinkers, and tavern haunters." Its onset was quick and its termination rapid, the victim generally dying within twenty-four hours; while the mortality was so great that in many parts of the country half of the male adult population were swept away. During the latter part of the fifteenth century, and the first half of the sixteenth, this pestilence reappeared no less than five times, its last visitation having occurred in 1551. Yet it must not be forgotten that this sixteenth century, with its long list of ravaging diseases, gave us, nevertheless, the heroes of the Elizabethan age, our triumph over Spain, and our English Reformation. But progress in sanitary defence was slow, tedious, and tentative. Indeed, the extraordinary vitality and indomitable pluck of the English race would almost appear to have been the sole defences against national decay and disaster, for during long years to come there was but little improvement in the homes or habits of the people. It was not until the Plague, which was the next great pestilence after the Sweating Sickness, had repeatedly devastated the country, and the great fire which swept away the crowded and filthy homes of London in 1666 occurred, that people began to appreciate, though in a faint and glimmering way, the principles of prevention. The plague died out with the fire, but smallpox, jail fever, malignant sore throat, ague, scurvy, and other controllable diseases, still continued to contribute to the excessive mortality of the seventeenth century.

But now we come to the dawn of a better day. The gradual improvements in agriculture, manufactures, and

commerce were adding steadily to the comforts of life. Food was becoming more plentiful, and the diet less coarse. Vegetables, and more especially the potato, were becoming much more generally used; fresh meat was taking the place of salted meat, which had hitherto constituted such a large part of the English dietary; while tea and coffee were to some extent replacing the strong ale and ardent spirits which had formerly proved such a baneful source of disease. People, too, were beginning to recognise the value of cleanliness of person and home. The introduction of soap and soda made washing easier, and cotton and linen articles of clothing were gradually coming into more general use. Thus far, then, it may be said that the seventeenth century, although characterised by no great advance in sanitary progress, witnessed, nevertheless, some considerable improvements of an incidental and indirect kind. The gradual emancipation from the thraldom of filth had begun, and precautionary measures against the spread of disease in the form of a rough-and-ready system of quarantine were here and there attempted. But the great purifier of the century was the memorable fire of London, which consumed everything from the Tower to Temple Bar, destroying 81 out of the 97 parishes within the city boundaries, and two of the parishes outside the walls. The old wooden houses with their overhanging stories, and the huge signboards swinging across the narrow, winding, filthy, unpaved streets, were swept away; and though the model city which Sir Christopher Wren had planned was not destined to be realised, better houses were constructed, wider streets laid out, and sanitary conditions in other respects were considerably improved.

Coming now to the health history of the eighteenth century, we find that three terrible scourges, namely, the Black Death, the Sweating Sickness, and the Plague, have

finally disappeared from the bills of mortality. And their disappearance, as we have seen, is not to be attributed to any conscious or well-sustained efforts in the way of prevention, but to the silent influence of the onward progress of civilisation. We now, however, enter upon an era in which observation and induction begin to play a part in the prevention of human suffering, when the physical causes of disease receive fuller appreciation, and when it is at last recognised that these causes can be inquired into and dealt with in a scientific manner. It is true that the workers were few, but the results of their labours have been fraught with untold blessings to humanity. Foremost amongst these pioneers of sanitary science we find the honoured names of Captain Cook, John Howard, and the immortal Dr. Jenner; and now let us glance briefly at the good work which they accomplished.

Captain Cook's name is associated with the suppression of the once prevalent disease—scurvy; a disease which, up to the latter half of the eighteenth century, decimated our armies and fleets, and often proved terribly fatal amongst the civil population. It is a disease easily recognised and well defined; fostered, as many other diseases are, by insanitary conditions; but its real cause is a diet from which vegetables and fruits have been excluded, and therefore its prevention or cure depends upon a proper supply of vegetable food or vegetable juices. It is true that all this had been known or surmised long anterior to the period in question; but it was reserved for Captain Cook, in his first voyage of discovery round the world, from 1772 to 1775, to prove beyond a doubt that the disease could be banished from every ship's crew, and that it could be entirely eradicated on land and sea. Hitherto it had been a cause of great mortality amongst seamen; and, to quote one instance out of many, in Anson's famous expedition some thirty years previous to

that of Captain Cook, out of a total number of 900 hands 600 died before the expedition returned, and chiefly from scurvy. During Captain Cook's three years' voyage, on the other hand, there were only four deaths, namely, three from accident and one from consumption, out of a total number of 118 men. Captain Cook thus earned for himself a foremost place amongst the sanitary reformers of the eighteenth century; but the nation took years to learn the lesson which he taught, and many more lives had to be sacrificed before it became compulsory that lime-juice should form a part of the commissariat of every sea-going vessel. Scurvy, too, may now be reckoned among the diseases of the past, although it occasionally reappears, as in a recent Arctic expedition, but only through blamable neglect or some other mishap.

The next great reformer deserving of special notice was the great and good John Howard. His name, as every one knows, is associated with the prevention of a fatal disease, then known as the jail-fever, which was constantly breaking out in prisons all over the country, had often invaded our courts of law, and made several assizes memorable as the Black Assizes, and which was continually spreading by means of infection, through the agency of discharged prisoners and debtors, amongst all classes of the community. The disease has long since been recognised to be the same as typhus fever, and John Howard lived the life of an apostle and died a martyr in proving that it is a disease which is essentially due to filth and overcrowding. Without enlarging on the incidents of his self-sacrificing labours, the outcome of them is simply this—that for years back the prisons of this country have been proved by the most rigid statistics to be far healthier than our homes, and that so-called preventable disease of any kind is of such rare occurrence within their walls, that when any isolated cases do appear

they at once give rise to surprise, and are sure to call for inquiry.

The next great sanitary triumph of the eighteenth century calling for special notice was the discovery of vaccination. That most hideous and terribly fatal disease, smallpox, had long been a terror and scourge to all classes of the community here and abroad, and after the disappearance of the Plague became the severest epidemic of the country. The introduction of the practice of inoculation at the instance of Lady Mary Wortley Montagu, the wife of the English Ambassador at Constantinople, which took place somewhere about the year 1720, while it modified the severity of the disease, assisted rather than otherwise its spread. But whether this was so or not, we find from the bills of mortality of the time that during the ten years 1771 to 1781 smallpox was the cause of 100 out of every 1000 deaths in London, and there is reason to believe it was quite as fatal in other parts of the country. The practice of vaccination, Jenner's grand discovery, was commenced in the year 1796, and although it was several years afterwards before it became general, its value as a preventive measure was not long in declaring itself in a steadily declining mortality. Thus, according to well-authenticated returns, while the mortality was 88 per 1000 deaths in the last ten years of the eighteenth century, it has fallen progressively from 64 to 11 per 1000 deaths during the first six decades of the present century. And if we have still recurrent outbreaks of the disease, it is because there are thousands of people living at the present day who never have been protected by vaccination, and many thousands more who have been imperfectly vaccinated. For it should be remembered that it was not till 1840 that we had any vaccination laws at all; not till 1853 that vaccination was provided gratuitously for the poor;

and not till 1867 that vaccination was made compulsory amongst children generally. We may therefore expect occasional outbreaks, though of constantly decreasing severity, for years to come; but that the disease can and will be finally eradicated, the belief is as deep-rooted and strong in the minds of medical men and of the educated public of the present day as it was in the stout brave heart of Edward Jenner.

In addition to these great sanitary triumphs of the eighteenth century there were others, such as improvements in ventilation and better house accommodation, which were also contributing their share in lessening the general death-rate, and especially in the reduction of fevers of all kinds. Diseases amongst infants and young children were much less fatal at the close than at the beginning of the century, while the labours of John Howard were beginning to tell on the home habits of the people, as they had already told on the vast improvement which had been effected in the sanitary condition of prisons and jails. The health of our soldiers and sailors was much better cared for, and the sickness and mortality greatly reduced. Altogether the progress made in the actual prevention of disease was very considerable; and accordingly we find from the bills of mortality that the death-rate of the city of London, which in the seventeenth century was over 80 per 1000, had been reduced to 50 per 1000, and for some years back it has averaged only 22 per 1000.

Coming now to the beginning of the present century, we find the country engaged in that long fierce struggle with France which culminated in the victory of Waterloo; yet, in spite of the constant drain in men and money, the population kept steadily increasing and the public health slowly improving. But outside London there were no large towns teeming with overgrown populations—none

contained so many as 100,000 inhabitants, and only five exceeded 50,000. By and by, however, there came a sudden and unprecedented change in the social history of the country. The discovery of steam-power opened up new sources of industry of almost unlimited extent and variety. Commerce flourished as it had never flourished before; wealth accumulated; work became plentiful; living became easier; early marriages were encouraged; and the rapid increase of population begun then has continued ever since. The population of England and Wales, which, in round numbers, was only ten millions in 1810, had increased to over fifteen millions in 1838; and at the present day it amounts to over twenty-seven millions. And this enormous increase, it should be remembered, has taken place almost exclusively in already populous towns, or at centres of industry which speedily became populous. But under what conditions? For the most part in the dust and din of factories; the vitiated air of mines; the stifling atmosphere of workshops; the bustle of busy warehouses; and when the day's work was done, in overcrowded houses or underground cellars, heaped together in filthy, narrow, and unventilated streets or reeking back slums. Even in the construction of better class houses the veriest rudiments of sanitation were neglected, because they were still but little understood and less appreciated. Instead of municipal control there was general apathy. Sewers had to be constructed, but they were of the worst possible description, uneven, leaky, unventilated, and incapable of being flushed, while the house drains leading into them were quite as faulty and imperfect. Scavenging was neglected, filth accumulated everywhere, cess-pits multiplied, and wells became polluted. But why fill up the disgusting details of the picture? The mischief was done, and in spite of recent improvements and legislative enactments, it will take

years of steady, earnest, sanitary work, and millions of money, to undo it. The money, no doubt, will be forthcoming, and the cleansing of the Augean stables may be accomplished in time; but the squalor, the misery, the disease, the physical deterioration, and the moral degradation engendered, have imposed a load of vitiated heritage which will tell on generations yet unborn, and which at the present day is crushing thousands of children into an early grave.

Meanwhile the Legislature had done nothing, or next to nothing, to mitigate the terrible evils which were fast accumulating. With the exception of the Factory Act of 1833, and the Poor Law Amendment Act of the following year, no public measures of general importance had been attempted, and even these were haphazard and tentative. It is true that here and there local Acts had been applied for and granted by Parliament to empower town authorities to provide water-supply and drainage, but it was not till those wonderful series of returns of the Registrar-General, and the masterly reports of the late lamented Dr. Farr, began to be published, that public attention became thoroughly aroused. At last, thanks to the incessant labours of Edwin Chadwick, Dr. Farr, Dr. Southwood Smith, Dr. Guy, and other pioneers of sanitary progress, the Health of Towns Commission was appointed, and their first report appeared in 1844,—a report in which the relations of cause and effect, as applied to disease, were made so glaring and manifest, that among the intelligent portions of the community there arose a loud cry for legislative interference. Things are still bad enough in the present day, but few can form any adequate conception of the deplorable sanitary condition of the country when that report was published. From every large town to which the long list of queries was sent, there came, with but little variation, the same terrible series

of replies—bad drainage, polluted water, unhealthy houses, overcrowding, filth everywhere; and, as a consequence, an excessive death-rate, with fever and filth-diseases of every description adding enormously to the death-roll. But so powerful were vested interests, and so strong the opposition to interfere with the liberty of the subject or of corporate bodies, that it was not till the country was threatened with a second visitation of cholera as severe as the epidemic of 1831, that Parliament became alarmed and passed the Public Health Act of 1848. Under this Act the General Board of Health was constituted, with a staff of inspectors who were empowered to hold public inquiries and report on the sanitary condition of towns which, according to the returns of the Registrar-General, showed an excessive rate of mortality. The Act itself was eventually adopted or enforced in a great many towns throughout the country; but as it was of a permissive nature, like the great majority of the sanitary Acts which followed it, the beneficial results which might have been expected to accrue from it were long in appearing, and were by no means general. Nevertheless, it originated an era of active sanitary improvement in most of our large towns, and it merits special notice as the first outspoken recognition on the part of the Legislature that the health of the State concerns the statesman. By enabling town authorities to borrow money and spread the expense of public works over a number of years, it removed one of the greatest obstacles to sanitation, and, as a consequence, extensive schemes of sewerage and water-supply were soon undertaken in many parts of the country. But, unfortunately, the engineers of those days largely shared the general ignorance of sanitary principles which then prevailed. Sewers were badly constructed, insufficiently ventilated, and unflushed; many of them, in fact, were elongated cesspools, and the sewage itself, collected at one or more out-

falls, was discharged into the nearest stream, thereby creating a general befoulment of our rivers, which, in spite of numerous injunctions, became so serious as to call for a special Act, which was passed in 1876 under the title of the Rivers Pollution Act.

Among other Acts which followed the Public Health Act of 1848 may be mentioned the Common Lodging-Houses Act of 1851, the Labouring Classes Lodging-Houses Act of the following year, the Metropolis Management Act of 1855, and the Nuisances Removal Act and the Diseases Prevention Act, both of the same year. But during the interim the nation had been learning another terrible lesson in sanitation. The horrors of the Crimean war, engendered by a faulty commissariat, an utter neglect of scavenging and cleanliness, and an incredible disregard of the most rudimentary laws of health, at last aroused and excited the public mind to the point of indignation, and so in 1857 was instituted the Royal Commission on the Health of the Army. Their report, which is still of the greatest value, was soon followed by the reports of the Barrack and Hospital Commission, and of the Commission on the Health of the Army in India, all of which demonstrated in the most complete manner that the sick-rate and death-rate of the army were culpably excessive; while the adoption of their recommendations, under the able teaching of the late lamented Dr. Parkes, afforded such conclusive proofs of the grand policy of prevention, that a stimulus to sanitary reform began to permeate the more intelligent classes among the general community which has continued to increase ever since.

The powers of the General Board of Health were transferred by Act of Parliament to the Privy Council in 1858, and in the same year the Local Government Board Act was passed, which consolidated to some extent the previous Sanitary Acts which were in force. The ap-

pointment of Mr. Simon as medical officer to the Privy Council, with his able staff of medical inspectors, inaugurated a new era in civil life. The material causes of disease were investigated with a minuteness and completeness of detail which could not fail to influence the most sceptical, and the series of reports in which these investigations are embodied and commented on have become the classics of sanitary literature. To any one who takes the trouble to read these reports, it becomes at once apparent that whatever of purely beneficial sanitary legislation which has subsequently come into force has all along been largely indebted to Mr. Simon's foresight and advocacy, based on the inquiries of such able co-adjutors as Seaton, Greenhow, Buchanan, Hunter, Thorne, Netten Radcliffe, Ballard, and others. Many of these inquiries will be specially alluded to in various parts of this work, but this brief historical sketch would be incomplete without referring to two discoveries in sanitary science which have already resulted in a vast amount of good, and are destined to be of still greater benefit to the nation. I allude to Dr. Snow's researches with regard to the etiology of cholera (see Chapter VIII.) and the differentiation between typhus and typhoid fever as regards causation and symptoms, and this last deserves special notice.

About the year 1848, when fever was plentiful enough in all our large towns, and did not spare country villages, the late Dr. Stewart, so well known for his contributions to sanitary literature, Sir William Jenner, and a few other earnest workers in hospital wards, began to observe that among the numerous cases of so-called typhus which came under their care there were many which presented symptoms of a more or less uniform character, but differing in many respects from those which characterised typhus fever. These symptoms soon came to be recog-

nised as those of typhoid or enteric fever, and subsequent inquiries have so clearly established the causes and mode of propagation of the fever that it is now regarded as a disease which is entirely preventable, and one which we have every reason to believe will eventually be as completely banished from our midst as the ague, which was once so common and now so rare. But it was urged by many, when this disease came to be talked about and written about, and was frequently found to be due to the entrance of sewer-air into houses, that in sewering a town public authorities only increased the danger, and that the money expended was worse than wasted. It is true that there was some show of foundation for this belief, but it has long since been made clear that any outbreaks of the disease which have been traced to sewer emanations were due not to the system itself, but to faulty sanitary engineering. Indeed, in the celebrated report of Dr. Buchanan, who was the inspector appointed to visit a large number of towns and make special inquiry into this subject, there was no point more clearly established than the remarkable reduction which had taken place in almost all the towns where a system of sewerage had been carried out. (See Chap. XII.)

Without referring to other important inquiries, such as those relating to unwholesome trades and occupations, food-adulterations, polluted water-supply, overcrowding and unhealthy house-accommodation, milk-contamination, and the wide-spread agency of filth in the causation of disease, we may note in passing the principal legislative measures which have recently been enacted to cope with these evils. And among these may be mentioned the Adulteration of Food and Drink Act of 1860; Amendments of the Factory Acts; the Sanitary Act of 1866; the Local Government Board Act of 1871, which vested in one central board the powers previously exercised by

the Poor Law Board and the Privy Council; and the Public Health Act of 1872. This last Act divided the country into urban and rural sanitary districts, and necessitated the appointment of medical officers of health and sanitary inspectors; while the Adulteration of Food Act, which was passed in the same year, authorised the appointment of public analysts. Then followed the Public Health Act of 1875, which consolidated the previously existing sanitary Acts; and in the same year were passed an amended Adulteration Bill, and the Artisans' and Labourers' Dwellings Act, intended to sweep away the rookeries in our large towns. The Rivers Pollution Act followed in 1876, the Canal Boats Act in 1877, the Public Health (Water) Act in 1878, and several other Acts have since been passed of minor importance. Reserving the consideration of the strictly medical aspects of these various Acts for a future chapter (see Chapter XVI.), it may be remarked in passing that, partly owing to the permissive nature of sanitary legislation, partly to the conflicting opinions and want of harmony which it is well known for a long time hampered the policy of the Local Government Board, and partly to the supineness of Local Authorities and their aversion to centralisation and Governmental interference, sanitary reform, in spite of all the obligations which the Legislature has imposed, and the measures to carry them out which it has provided, remains, comparatively speaking, at a standstill in many parts of the country. It is true that in many other localities there is abundant evidence of sound sanitary progress, but so long as the Public Health Service is allowed to continue in its present chaotic condition, so long will there be loopholes for the evasion of duty on the part of sanitary authorities, and inducements to remissness on the part of their officers.

This, however, by the way. Let us now consider for

a moment the vast amount of preventable disease with which sanitary science and sanitary legislation had to combat at the date of the passing of the Public Health Act, 1872. It was then estimated by Mr. Simon "That the deaths which occur in this country are fully a third more numerous than they would be if our existing knowledge of the chief causes of disease were reasonably well applied throughout the country; that of deaths, which in this sense may be called preventable, the average yearly number in England and Wales is about 120,000; and that of the 120,000 cases of preventable suffering which thus in every year attain their final place in the death-register, each unit represents a larger or smaller group of other cases in which preventable disease, not ending in death, though often of far-reaching ill effects on life, has been suffered. And while these vast quantities of needless animal suffering, if regarded merely as such, would be matter for indignant human protest, it further has to be remembered, as of legislative concern, that the physical strength of a people is an essential and main factor of national prosperity; that disease, so far as it affects the workers of the population, is in direct antagonism to industry; and that disease which affects the growing and reproductive parts of a population must also in part be regarded as tending to deterioration of the race.

"Then there is the fact that this terrible continuing tax on human life and welfare falls with immense over-proportion upon the most helpless classes of the community; upon the poor, the ignorant, the subordinate, the immature; upon classes which, in great part through want of knowledge, and in great part because of their dependent position, cannot effectually remonstrate for themselves against the miseries thus brought upon them, and have in this circumstance the strongest of all claims on a

legislature which can justly measure, and can abate, their sufferings.

"There are also some indirect relations of the subject which seem to me scarcely less important than the direct. For where that grievous excess of physical suffering is bred, large parts of the same soil yield, side by side with it, equal evils of another kind, so that in some of the largest regions of insanitary influence, civilisation and morals suffer almost equally with health. At the present time, when popular education (which indeed in itself would be some security for better physical conditions of human life) has its importance fully recognised by the legislature, it may be opportune to remember that, throughout the large area to which these observations apply, education is little likely to penetrate, unless with amended sanitary law, nor human life to be morally raised while physically it is so degraded and squandered." (See *Thirteenth Report of the Medical Officer of the Privy Council.*)

Or, to take another illustration. According to the supplement to the forty-fifth annual report of the Registrar-General published in 1885, there are eight registration districts in England and Wales in which the mean annual death-rate during the decade 1871-80 was under 15 per 1000, thirty-one more in which it was under 16, and sixty-two others in which it was under 17. In 326 other districts the mean annual death-rate was between 17 and 20; in 195 it was from 20 to 25; in twenty-three, from 25 to 30; while in the remaining two, out of a total of 647 districts, it exceeded even this high figure. It therefore appears that there are influences inimical to life prevailing to a far greater extent in some parts of the country than in others, and a closer analysis of the national death-register demonstrates still more clearly that this excess of mortality is for the most part due to diseases which in other

ways are known to be preventable, and which detailed medical inspections in various localities, at the instance of the Privy Council and the Local Government Board, have proved to be dependent upon causes which are not only removable, but whose very existence constitutes an offence against sanitary law. These causes have been grouped by Mr. Simon into two great classes, namely, local conditions of filth and nuisance polluting air and water, and reckless disseminations of contagion; and as regards both these wide fields of disease-causation, the various enactments embodied in the Consolidated Health Act of 1875 have conferred extensive powers upon sanitary authorities throughout the country to remove the former, and to see that protective measures and penal checks are fully and fairly carried out with regard to the latter.

But there are some pessimists who have maintained that because the average death-rate of the country remained stationary, with comparatively slight fluctuations, at a little over 22 per 1000 from 1841 to 1870, preventive measures and the vast sums which have been expended on sanitary improvements are alike powerless to increase the mean duration of life. They appear to regard the average age at death which prevailed during that period, as the "limit which nature in her wisdom" has prescribed, and that we have no grounds for believing that public sanitation will ever materially lessen the persistently heavy death-roll of the nation. But such an argument, as has already been made evident, is based on inferences which a closer analysis of vital statistics proves to be altogether untenable. It has been previously shown, for example, that the death-rate in London has been lowered from 80 per 1000 in the seventeenth century, to 50 per 1000 during the past century, and to 22·4 per 1000 in the decade 1871-80, while the Registrar-General's returns show that the annual rate for the five

years (1881-85) averaged only 19·3 per 1000. Then, again, we find that during recent years the death-rate has been very considerably lowered in many other towns throughout the country, and that this diminished death-rate has admittedly and unmistakably been brought about by the sanitary improvements which have been carried out. This is well illustrated by the following table :—

Districts of England and Wales, showing some improvement in the Annual Rate of Mortality in the Four Decades, 1841-50, 1851-60, 1861-70, 1871-80.

Name of District, etc.	Registration County.	Enumerated Population.	Average Annual Mortality. Deaths to 1000 living.			
		1871.	1841-50.	1851-60.	1861-70.	1871-80.
North Witchford .	Cambridge .	15,585	27	21	20	18·8
Whittlesey . .	Cambridge .	7,002	25	23	21	20·0
Wisbech . .	Cambridge .	34,209	25	22	20	19·3
Orsett . . .	Essex. .	13,172	24	21	18	16·5
Salisbury . .	Wilts. .	9,212	28	24	20	20·7
Stoke Damerel .	Devon .	49,449	26	23	21	20·4
Wolverhampton .	Stafford .	136,053	27	28	24	22·7
Coventry . .	Warwick .	40,113	27	25	21	21·5
Macclesfield . .	Chester .	59,339	26	25	23	23·2
Hull . . .	York . .	68,316	31	25	26	24·5
Merthyr Tydfil .	Glamorgan .	104,239	28	29	25	24·2
Crickhowell . .	Brecknock .	20,147	27	25	23	23·0

It is no doubt true that these and similar reductions which have taken place in many other localities have been counterbalanced by increased death-rates, chiefly in the newer towns which have sprung up so rapidly in mining and manufacturing districts; but considering the evils attendant upon overcrowding, and the utter neglect of all sanitary principles or precautions, it may be fairly argued that even a stationary average death-rate ought to be accepted as proof of progress. Moreover, it should be borne in mind that organised sanitary supervision and

general local administration do not date further back than the Public Health Act, 1872, and that therefore the results have not yet had sufficient time to declare themselves, because the evils to be combated were so enormous, and the supineness to encounter them is in many parts of the country still so apparent. Notwithstanding all this, however, it is satisfactory to note that, apart from a diminution of the death-rate in particular localities, there has been a real and sensible decline in the average recorded death-rate of England and Wales during the past few years. Thus, while the average annual death-rate during the thirty years 1841-1870 was 22·37 per 1000, the average death-rate during the period 1871-1875 was 22, while during the five years 1876-1880 it had fallen to 20·8, and during the first half of the current decennium it has averaged only 19·3. And this latest reduction in the death-rate implies that more than 281,000 persons in England and Wales have survived the last five years whose deaths would have been recorded had the mean rate of mortality been equal to that prevailing in the ten years 1871-80. But coincident with a reduction of the general death-rate it is also satisfactory to find from the same returns that the mean annual death-rate from the seven principal zymotic diseases, which had been 3·87, 4·11, and 3·36 per 1000 respectively in the three decades 1851-60, 1861-70, 1871-80, did not exceed 2·40 in the first five years of the current decennium; while the death-rate from fever alone did not exceed 0·27 per 1000, whereas in the three most recent decades it was equal to 0·91, 0·89, and 0·49 respectively. This remarkable reduction in the death-rate from fever, mostly enteric, affords the strongest possible evidence of the beneficial results which follow in the wake of improved sanitation.

But in order to carry on this combat against prevent-

able disease to a successful issue, we want a thoroughly organised Public Health Service, with efficiently trained health officers who shall be debarred from private practice, and competent sanitary inspectors, all of them holding permanent appointments under the control of the Local Government Board. We also want hospital accommodation within easy access in every populous district for the isolation of cases of infectious disease, and compulsory and early information of all such cases; and we want, moreover, what is still very hard to get, the active and intelligent co-operation of the people themselves in improving and maintaining the sanitary condition of the home and its surroundings.

CHAPTER II.—FOOD

Section I.—Functions and Constituents of Food

Without entering into a discussion of the various chemico-physical changes which food undergoes in the living body, it may be broadly asserted that its ultimate destiny is the development of heat and other modes of motion, which together constitute the physiological phenomena of animal life. The potential energy with which the food is stored becomes converted into actual or dynamic energy, and is manifested in the body as heat, constructive power, nervo-muscular action, mechanical motion, and the like. But as food also supplies the materials which are requisite for the development and maintenance of the living fabric, as well as for the display of its various kinds of active energy, it may be inferred that inorganic and organic substances are both necessary. The organic alone are oxidisable, or capable of generating force; while the inorganic, though not oxidisable, are essential to the metamorphosis of organic matter which takes place in the animal economy.

The organic constituents of food are generally divided into nitrogenous, fatty, and saccharine compounds; and the inorganic into water and saline matters. Both classes of constituents are present in all ordinary articles of diet, whether they be derived from the animal or vegetable kingdom.

1. *Functions of the Nitrogenous Constituents.*—The

nitrogenous constituents consist of albumen in its various forms, fibrine, syntonin or muscle-fibrine, casein, gluten, legumin, and other allied substances, such as gelatine. Their chemical composition is remarkably uniform, and, as they seem all capable of being reduced by the digestive process to a like condition, they can replace each other in nutrition, though not to an equal extent.

Up to a comparatively recent period it was believed that nitrogenous constituents must first be converted into tissue before their dynamical energy can be elicited; in other words, that muscular force is entirely dependent on the metamorphosis of muscular tissue, and that urea, being the product of the change, ought to be regarded as a measure of the force. This was the doctrine taught by the late Professor Liebig, and it was generally accepted by physiologists until Drs. Fick and Wislicenus of Zurich published their famous experiments connected with their ascent of the Faulhorn. While these experiments proved that a non-nitrogenous diet will sustain the body during severe exercise for a short period, and without any notable increase in the amount of urea, the more carefully conducted experiments subsequently made by the late Dr. Parkes showed that *possibly* the amount of urea is even lessened. If this view were confirmed, Dr. Parkes' inference would be rendered highly probable—the inference, namely, that muscle, instead of oxidising during labour, and becoming wasted by losing nitrogen, does in reality appropriate nitrogen, and grows, and that its exhaustion does not depend so much on decay for the time being, as on an accumulation of the oxidised products of other food constituents within its tissues. He takes care to point out, however, that in the long run some decay of muscle does take place, and that the amount of nitrogen must be increased as the work increases. The still more recent researches of Dr. Pavey in the case of Mr. Weston, so well

known for his pedestrian feats, appear to indicate that at the commencement of a prolonged muscular effort, the nitrogen excreted is considerably increased, and that subsequently it will vary pretty much according to the amount contained in the food consumed from day to day.

Judging from these and other experiments, it would therefore appear that, although the main functions of the nitrogenous constituents of food are the construction and repair of the tissues, they exercise other important functions of a regulative and dynamic nature not well defined. There is no doubt that a certain portion of them is directly decomposed in the blood, and so far they contribute to the maintenance of animal heat and the development of dynamic energy; but the experiments of Pettenkofer and Voit also tend to show that the nitrogenous substances composing the tissues determine the oxidation of the other constituents, or, in other words, that no manifestation of force is possible without their participation in the process.

2. *Functions of the Fatty Constituents.*—the fact that food containing a large proportion of fatty ingredients is invariably used by the inhabitants of cold countries, indicates that these constituents play an important part in the maintenance of animal heat. Indeed, it has been proved by experiment that the respiratory or heat-producing powers of fat are twice and a half as great as those of the other hydrocarbons, as starch or sugar. Fat also takes an active share in the conversion of food into tissue, and aids the removal of effete products from the system. The experiments already alluded to likewise show that its oxidation in the blood generates to a great extent the force which is rendered apparent in locomotion or manual labour. Further, its distribution in the tissues gives rotundity to the form, serves to retain animal heat by its non-conducting properties, and greatly facilitates the working of the

various parts of the living machine by lessening friction and preventing jarring by its elasticity.

3. *Functions of the Saccharine Constituents or Hydrocarbons.*—These constituents comprise cellulose, starch, and sugar; and, like the fatty constituents, are directly subservient to the maintenance of animal heat and the production of animal force. Starch is for the most part converted into dextrine, and by a further oxidation generates carbonic acid, which is given off by the lungs. As already stated, the heat-producing powers of these constituents are much inferior to those of fat, but they are capable of being converted into fat in the system, and are largely concerned in carrying on the digestion of nitrogenous substances.

4. *Functions of Water and Saline Matters.*—The principal functions of water in the animal economy are—the solution and conveyance of food to different parts of the system, the removal of effete products, the lubrication of the tissues, the equalising of the body temperature by evaporation, and the regulation of the chemical changes which take place in the processes of nutrition and decay. Saline matters, on the other hand, are the chief media for the transference of the organic constituents throughout the body. They are largely concerned in the consolidation of the tissues, and are supposed to convert unabsorbable colloids into highly diffusive crystalloids.

The functions of what are called the accessories of food, such as beverages, stimulants, etc., are still matters of speculation.

That all these four classes of constituents should be present in a well-arranged dietetic scheme is alike taught by experience and proved by experiment. No single class is capable of sustaining life by itself, although it is certain that health can be maintained for some time on a diet consisting of the nitrogenous, fatty, and saline matters.

The separate amounts and relative proportions of the several classes of constituents required in a standard diet for a healthy male European adult, of average size and weight, and performing a moderate amount of work, are given in the following table :—

Amounts.		Grammes.	Relative Proportions.
Water-free Substances given daily.	Ounces avoir.		
Nitrogenous substances .	4·587	130	1
Fatty ,, .	2·964	84	·6 nearly.
Saccharine ,, .	14·257	404	3
Saline ,, .	1·058	30	·2
Total water-free food .	22·866	648	

Although no single standard will meet all cases, the above, which is quoted from Moleschott's numbers, is found to accord fairly with the observations of numerous other physiologists.

Section II.—Nutritive Values of Food.

As the phenomena of nutrition depend mainly on the chemical interchanges of nitrogen and carbon with oxygen, different articles of diet have been estimated according to the amount of nitrogen and carbon which they contain. But inasmuch as the actual value of the carbonaceous compounds in fatty constituents is about two and a half times as great as that of the saccharine constituents, it is evident that, in framing a table of alimentary equivalents, the amount of carbon must be stated as having the same nutritive value throughout. In the following table, therefore, which is taken from the late Dr. Letheby's valuable work on *Food*, the amount of carbonaceous matters in the different articles of diet is estimated as starch :—

	GRS PER POUND.	
	Carbon.	Nitrogen.
Split peas	2699	248
Indian meal	3016	120
Barley meal	2563	68
Rye meal	2693	86
Seconds flour	2700	116
Oatmeal	2831	136
Bakers' bread	1975	88
Pearl barley	2660	91
Rice	2732	68
Potatoes	769	22
Turnips	263	13
Green Vegetables	420	14
Carrots	508	14
Parsnips	554	12
Sugar	2955	—
Treacle	2395	—
Buttermilk	387	44
Whey	154	13
Skimmed milk	438	43

	GRS. PER POUND.	
	Carbon.	Nitrogen.
New milk	599	44
Skim cheese	1947	483
Cheddar cheese	3344	306
Bullock's liver	934	204
Mutton	1900	189
Beef	1854	184
Fat pork	4113	106
Dry bacon	5987	95
Green bacon	5426	76
White fish	871	195
Red herrings	1435	217
Dripping	5456	—
Suet	4710	—
Lard	4819	—
Salt butter	4585	—
Fresh butter	6456	—
Cocoa	3934	140
Beer and Porter	274	1

As this table contains almost all the articles which are likely to be met with in a common dietary, it becomes no difficult matter to calculate the total amount of carbon and nitrogen which any such dietary yields, and to compare the results with other dietaries that have been calculated in the same way. It is necessary to add that the nutritive equivalents apply to articles in their uncooked state, and that the meat is boned.

Section III.—Food and Work.

It has already been stated that, in addition to maintaining the body in a healthy state, the potential energy of food is the sole source of the active energy displayed in mechanical motion or work. It therefore follows that the diet must be increased as the work increases; and the question arises at the outset, What is the minimum

amount of food on which a man of average size and weight can subsist without detriment to health? From a large number of observations made by Sir Lyon Playfair and others on the dietaries of prisons and workhouses, and by the late Dr. Edward Smith on the amounts of food consumed by the Lancashire operatives during the cotton-famine, it would appear, according to Dr. Letheby, that a barely sustaining diet should contain about 3888 grains of carbon and 181 grains of nitrogen. In round numbers, and taking a somewhat liberal view of the question, Dr. Edward Smith has proposed the following averages, as representing the daily diet of an adult man and woman during periods of idleness :—

	Carbon (grains).	Nitrogen (grains).
Adult man . .	4300	200
Adult woman . .	3900	180
Average adult .	4100	190

These are the proportions which, according to Dr. E. Smith's researches, are actually required to avert starvation diseases; and they are represented in the case of a man's diet by 22 oz. of carbonaceous food, with 2·97 of nitrogenous.

Taking the mean of all the researches which have been made by eminent physiologists, Dr. Letheby has given the following as the amounts required daily by an adult man for idleness, for ordinary labour, and for active labour :—

Daily diets for	Nitrogenous. Ozs.	Carbonaceous. Ozs.		Carbon. Grs.	Nitrogen. Grs.
Idleness . .	2·67	19·61		3816	180
Ordinary labour	4·56	29·24	=	5688	307
Active labour .	5·81	34·97		6823	391

Very often the standard for a healthy adult employed at ordinary labour is stated as 20 grammes of nitrogen, and

300 grammes of carbon, equivalent to 308·6 and 4629 grains respectively.

And here it may be observed that the general correctness of these averages is fully borne out by the results of the numerous experiments which have been made to ascertain the amount of carbon and nitrogen actually excreted by adult men under different conditions of diet and exercise. These results have also been summarised by Dr. Letheby, and the averages are found to correspond very closely with those just given, thus :—

Daily Requirements of the Body (LETHEBY).

	Nitrogenous Food. Ozs.	Carbonaceous Food. Ozs.	Carbon. Grs.	Nitrogen. Grs.
During Idleness as determined — By dietaries	2·67	19·61	= 3816	180
During Idleness as determined — By excretions	2·78	21·60	= 4199	187
Average	2·73	20·60	= 4005	184
Routine work as determined — By dietaries	4·56	29·24	= 5688	307
Routine work as determined — By excretions	4·39	23·63	= 4694	296
	4·48	26·44	5191	302

The first of these averages is represented by 2 lbs. 2 oz. of bread; and the second by about $3\frac{1}{2}$ lbs., or 1 lb. of butcher meat with about $4\frac{1}{4}$ lbs. of bread.

The actual amounts of carbonaceous and nitrogenous matters which are consumed by low-fed and well-fed operatives are given in the following tables :—

Weekly Dietaries of Low-fed Operatives, calculated as Adults (Dr. E. Smith).

Class of Labourer.	Bread Stuffs.	Potatoes.	Sugars.	Fats.	Meat.	Milk.	Cheese.	Tea.	Containing	
									Carbon.	Nitrogen.
	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Grs.	Grs.
Needle Women (London)	124·0	40·0	7·3	4·5	16·3	7·0	0·5	1·3	22,900	950
Silk-weavers (Coventry)	166·5	33·7	8·5	3·6	5·3	11·6	1·0	0·3	27,028	1104
Silk-weavers (London)	158·4	43·8	8·8	5·5	11·9	4·3	0·3	0·6	48,288	1165
Silk-weavers (Macclesfield)	138·8	26·6	6·3	3·4	3·2	41·9	0·9	0·3	27,346	1177
Kid-glovers (Yeovil)	140·0	84·0	4·3	7·1	18·3	18·3	10·0	0·9	28,623	1213
Cotton-spinners (Lancashire) . . .	161·8	22·6	14·0	3·1	5·0	11·8	0·7	0·7	29,214	1295
Hose-weavers (Derbyshire)	190·4	64·0	11·0	3·9	11·9	25·0	2·2	0·4	33,537	1316
Shoemakers (Coventry)	179·8	56·0	10·0	5·8	15·8	18·0	3·3	0·8	31,700	1332
Farm labourer (England)	196·0	96·0	7·4	5·5	16·0	32·0	5·5	0·5	40,673	1594
Farm labourer (Wales)	224·0	138·7	0·5	5·9	10·0	85·0	9·8	0·5	48,354	2031
Farm labourer (Scotland)	204·0	204·0	5·8	4·0	10·3	124·8	2·5	0·7	48,980	2348
Farm labourer (Ireland)	326·4	92·0	4·8	1·3	4·5	135·0	—	0·3	43,366	2434
Mean of all . . .	184·2	78·1	8·0	4·5	10·7	42·9	3·1	0·6	34,167	1500
Average per day	26·3	11·1	1·1	0·6	1·5	6·1	0·4	0·1	4,881	214

Daily Dietaries of Well-fed Operatives (PLAYFAIR).

Class of Labourer.	Flesh-formers.	Fats.	Starch and Sugar.	Containing		Containing	
				Carbonaceous.	Nitrogenous.	Carbon.	Nitrogen.
	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Grs.	Grs.
Fully-fed tailors .	4·61	1·37	18·47	21·64	4·61	5136	325
Soldiers in peace .	4·22	1·85	18·69	22·06	4·22	5246	297
Royal Engineers (work) . . .	5·08	2·91	22·22	29·38	5·08	6494	358
Soldiers in war .	5·41	2·41	17·92	23·48	5·41	5561	381
English sailor . .	5·00	2·57	14·39	20·40	5·00	4834	252
French sailor . .	5·74	1·32	23·60	26·70	5·74	6379	405
Hard-worked weavers . . .	5·33	1·53	21·89	25·42	5·33	6020	375
English navvy (Crimea) . . .	5·73	3·27	13·21	21·06	5·73	5014	404
English navvy (Railway) . .	6·84	3·82	27·81	37·08	6·84	8295	482
Blacksmiths . .	6·20	2·50	23·50	29·50	6·20	6864	437
Prize-fighters (training) . .	9·80	3·10	3·27	10·70	9·80	4366	690
Mean of all . .	5·81	2·42	18·63	24·31	5·81	5837	400
Mean of low-fed operatives .	3·04	0·64	21·18	22·78	3·04	4881	214

As an addendum to these data, and by way of contrast, I may here give some particulars with reference to the dietaries of the convicts confined in English prisons. In the hard-labour prisons, where the great majority of the prisoners are employed at active outdoor work, there are two scales of diet—viz. the light-labour diet, and the full-labour diet. When medical officer to the Portsmouth Convict Prison, I carefully calculated the nutritive values of the various articles of food contained in these diets, according to the equivalents given in a preceding table, and the results were as follows :—

	Daily Average.	
	Carbon, Grs.	Nitrogen, Grs.
Light-labour diet	4651	224
Full-labour diet	5289	255

Extended observation proved that the full-labour diet was inadequate to sustain prisoners employed at hard navvy work for any length of time, and their average loss of weight was so great that they had constantly to be shifted to lighter labour to enable them to recruit.

Section IV.—Construction of Dietaries.

By reference to the numerous data already given, it will not only be easy to calculate the nutritive value of any given dietary, but a reliable opinion may be formed as to its suitability as well as sufficiency under specified circumstances. It now remains to point out the more important principles which ought always to be kept in view in the construction of dietaries; and, apart from the influence of work, which has already been considered, they may be briefly summarised as follows:—

1. *Influence of Sex.*—In the case of in-door operatives, the dietaries of women should be about one-tenth less than those of men.

2. *Influence of Age.*—Up to nine years of age a child should be dieted chiefly on milk and farinaceous substances. At ten years of age it will require half as much nutriment as a woman; and at fourteen quite as much as a woman. Young men who have not reached their full growth, but who are doing the same amount of work as adult men, require more food than the latter.

3. *Selection of Food.*—This embraces a variety of considerations, such as—

(1.) *The relative proportions of proximate constituents.*—These have already been shown in Moleschott's numbers, and they correspond very closely with those given by Dr Letheby—viz. 22 of nitrogenous substances, 9 of

fat, and 69 of starch and sugar. Whether the diet be mixed or purely vegetable the same proportions hold good, and the results of experience prove that they are substantially correct. For example, articles of food which are deficient in one class of constituents are invariably associated with others which contain an excess of them. Thus we have butter, or milk, or cheese, with bread; bacon with veal, liver, and fowl; melted butter or oil with fish, and so on. Such combinations are also of great service in aiding the digestibility of food. For reasons to be afterwards stated, every dietary should contain fresh vegetables.

(2.) *Variety of Food.*—But even when the proper proportions of constituents are provided for in a dietary, it is further necessary that certain articles belonging to the same class be varied from day to day, otherwise the appetite cloys. Beef should alternate with mutton, for example; or variety may be secured by different modes of cooking the same article. Indeed, it is not too much to say that the art of cookery is a matter of national importance, not only because it renders food palatable, but because the more it is studied and practised the greater is the economy which may be effected. It is chiefly in this respect that beverages, condiments, etc., become such valuable dietetic adjuncts.

It may here be noted that, in apportioning rations of meat, 20 per cent must be allowed for bone. The loss in weight by cooking varies from 20 to 30 per cent.

(3.) *Digestibility.*—This also in great measure depends upon the mode of cooking.

(4.) *Price.*—For much practical information on this and other points see Dr. Edward Smith's *Practical Dietary*, or his report on the Food of the Lancashire Operatives, in the Fifth Report of the Medical Officer to the Privy Council.

4. *Number and Distribution of Meals.*—Experience teaches that three meals daily are best suited to the wants of the body. Dr. Edward Smith, in his physiological diet of 4300 grains of carbon and 200 of nitrogen, distributes the amounts as follows :—

	Carbon. grs.	Nitrogen. grs.		Carbonaceous. oz.	Nitrogenous. oz.
For Breakfast . . .	1500	70	=	6·62	1·04
For Dinner	1800	90	=	7·85	1·34
For Supper	1000	40	=	4·52	0·59
Total daily . . .	4300	200		18·99	2·97

5. *Climate.*—Other things being equal, carbonaceous substances ought to contain a preponderance of fatty constituents in cold climates, and of starchy or farinaceous in warm climates. This also applies to seasonal variations.

Section V.—Preserved Foods.

Only a few of these need be mentioned.

1. *Extractum Carnis.*—Liebig's extract is perhaps the best known, but there are several other extracts in the market of almost identical composition. According to Dr. Parkes, Liebig's extract is very restorative, removing all sense of fatigue after great exertion. Its nutritive qualities are inferior to those of ordinary beef-tea, but it can often be taken by an invalid when beef-tea would be rejected ; and it has the further advantage of being readily prepared. Brand's essence of meat and Nelson's preparations are also very highly commended.

2. *Preserved Meat.*—Weight for weight, preserved meat is not so nutritious as properly cooked fresh meat, because the process of preservation requires that it should be over-cooked. The great difference in price, however, more than compensates for this slight disadvantage, and

on the score of economy alone it deserves to be extensively used. Large quantities of it are now consumed in workhouses and asylums. It is best used cold, or warmed and mixed with potatoes and vegetables to form a stew; or it may be minced and warmed. In Dr. Williams' experiments in the Sussex County Asylum, the patients were allowed amounts equal to the uncooked fresh meat daily ration, with the result of a slight gain in weight in 13 of the 20 experimented on at the end of a month, the weight of the others remaining stationary.

Soups of various kinds, fish, poultry, game, are now sold in large quantities as preserved foods, while fresh meat is largely imported from Australia, New Zealand, and America in refrigerating chambers.

3. *Preserved Vegetables.*—When fresh vegetables cannot be procured in sufficient quantity, dried vegetables should be employed to make up the deficiency. In lieu of potatoes in the early part of summer, preserved potatoes may be used; but as they are apt to pall on the appetite, other substitutes, such as a mess of rice and cabbage, pease-pudding, or haricot beans, should be given on alternate days.

4. *Preserved Milk.*—Condensed milk as usually prepared consists of pure milk, or milk sweetened with a little sugar. As one volume of the condensed milk contains the nutritive material of four volumes of fresh milk, it should be diluted with three times its volume of water when used.

Section VI.—Examination of Food.

By Section 116 of the Public Health Act 1875, it is enacted that, "Any medical officer of health or inspector of nuisances may at all reasonable times inspect and examine any animal, carcase, meat, poultry, game, flesh,

fish, fruit, vegetables, corn, bread, flour, or milk, exposed for sale, or deposited in any place for the purpose of sale, and intended for the food of man." Without referring to the rules of seizure and legal proceedings which will be more conveniently dealt with in the Chapter on the Duties of Medical Officers of Health, it need hardly be said that this clause demands a thorough practical knowledge of the physical appearances of the various articles of food here enumerated in their various degrees of quality in order to be able to determine whether or not they are fit or unfit for human consumption. Indeed, with respect to animal food more especially, it frequently happens that no more difficult task can devolve upon the sanitary official than to have to decide whether the meat which he is called upon to examine comes from a diseased animal, and if so, to determine the nature of the disease. Even the well trained and experienced veterinary surgeon, when he is called in to decide, is often at fault. And yet it is most important in the interests of the public, that this traffic in diseased meat, which in spite of inspection is still carried on to a scandalous extent, and especially when infectious disease is prevalent among animals, should be kept in check. It will be well, therefore, at the outset to discuss somewhat in detail the leading symptoms and features of the principal diseases which affect animals whose flesh is used for human food; but before doing so it will be of advantage to indicate the main points which characterise healthy living animals, and, briefly summarised, they are these:—The animal's coat should be in good condition, the skin supple and free from scabs, pustules, or sores of any kind. The animal itself should be well-fed and able to move about without signs of stiffness or lameness. Its mouth and nostrils should be free from any discharge, and its breath from offensive odour, while the breathing should be easy and

noiseless. Its eyes should be bright, and it should give no signs of shivering or being in pain. If an animal has been driven far to market it will often become footsore, but the resulting lameness will easily be accounted for, and need not therefore be regarded with suspicion.

1. *Diseases which render the Flesh of Animals unfit for Human Food.*—The most prominent among these diseases are—cattle-plague, contagious pleuro-pneumonia, anthrax and anthracoid diseases, foot-and-mouth disease, varioloid disease, tuberculosis, measles, puerperal fever, acute rheumatism, rot in sheep, pig-typhoid, pig-measles, trichiniasis, fowl-cholera, and acute febrile disorders from whatever cause. To those who are desirous of making themselves more fully acquainted with this wide subject I would strongly recommend the perusal of Fleming's excellent *Manual on Veterinary Sanitary Science and Police,* from which much of the following information has been collated.

(1.) *Cattle-plague.*—This disease is highly contagious, but admittedly somewhat difficult to diagnose in its early stages. From the first onset, however, the temperature is variable and rises, the hair becomes dull and erect, the appetite fails, and after a time there is a frequent, dry, short, cough. The mucous membrane becomes red and soon covered with patches, and a glairy discharge sets in from the eyes, nose, and mouth, and, in cows and heifers, from the vulva. The ears droop, the secretion of tears becomes copious, there is much shivering and ephemeral muscular contraction, and the animal becomes very restless and sometimes delirious. In a short time purging sets in, and in most cases an eruption appears on the inside of the thighs, udder, and loins.

When the animal is killed the whole mucous tract is found to be reddened and congested, extravasations of blood are generally to be detected in the later stages on the intestines and heart, while the inside of the intestines

is covered with a blood-coloured glairy fluid. Except in advanced stages of the disease, the flesh is not much changed in appearance, but it does not set well. When the disease is well developed the flesh is dark, flabby, and has a disagreeable smell, and often crackles, owing to infiltration of air into the tissues.

The propriety of using the flesh of animals killed when suffering from this disease has been discussed for more than a century; and no doubt in this country during the epidemic of 1865-66, and in Paris after the Siege, there was a regular traffic in meat of this description without any recorded ill effects. Fleming maintains, therefore, that under exceptional circumstances it may be used without any very great precaution, but under the ordinary circumstances of every-day life, the medical officer of health should condemn it without the slightest hesitation.

(2.) *Contagious Pleuro-pneumonia*, though it sometimes attacks sheep and swine, is more especially a cattle disease. The early symptoms are generally slow and insidious, but from the first there is a rise in the temperature, the appetite becomes less keen, the coat becomes rough and loses its lustre, and eventually a dry, short cough sets in. Later on the breathing becomes laboured, and in coughing the back is arched, and the head and neck extended. At this stage, or even earlier, auscultation and percussion, more particularly over the lower lobes of the lung, will reveal the true nature of the disease. When the animal is slaughtered the pleuræ or lining membranes of the chest and lungs will be found to be rough and thickened, and covered more or less with fibrinous exudation, while the chest cavity is often distended with a large amount of semi-purulent fluid. In the early stages the lungs present a grayish appearance with red or purple patches, and they become less spongy.

Later on they are found to be dark and marbled in appearance, resisting and solid on section, and pieces cut off sink readily in water, while their weight is often increased ten or thirty pounds, or more.

The chief characteristic of the flesh is that it usually looks dark and harsh in appearance, the fat yellow tinged, and there is an absence of blood generally. In order to palm the meat off as sound meat, butchers often strip off the lining membrane from the walls of the chest and smear them with fat, but this artifice may be readily detected on examination. In 1880 a very warm discussion was aroused in consequence of the Metropolitan Board of Works sanctioning the sale of the flesh of animals slaughtered for pleuro-pneumonia as fit for human food; and though, no doubt, meat of this description has been eaten in large quantities with apparent immunity, it was urged that in adopting such a course more respect was paid to the views of veterinary surgeons than of medical men. But so far as the duties of medical officers of health are concerned, it will generally be found that, no matter whether the meat is much diseased or not, it is exposed for sale as sound meat, and as it is thus palmed off on the public under a fictitious character, there ought to be no hesitation in condemning it.

When the disease attacks the pig or sheep the same changes will be found in the lungs and on the pleuræ, while the intestines are often inflamed and marked here and there with dark patches.

(3.) *Anthrax and Anthracoid Diseases.*—From the remotest times these diseases have given rise to wide-spread and most fatal epidemics, not only among domesticated animals, but among many wild animals. The specific contagium is believed to be a characteristic *bacillus*, the *Bacillus anthracis*, and these *bacilli* crowd the blood of the diseased animal to such an enormous extent that as many

as eight or ten millions have been estimated to exist in a single drop. Fleming divides these diseases into two classes—the general and localised—the former known as splenic apoplexy or anthrax fever, and the latter as carbuncular or anthracoid erysipelas. Other writers, however, distinguish a third form, called *black-quarter* or *black-leg*, characterised by the swelling and dark-coloured appearance of one of the fore or hind quarters. In anthrax fever the disease generally runs a very brief course, sometimes the animals falling as if shot or slain. In other cases, the animals commence to tremble and stagger, the breathing becomes hurried, the pulse rapid, and there is a bloody discharge from the mouth, nostrils, and other passages. In the early stage of the disease there is usually marked thirst, and during the later stage the temperature falls.

Localised anthrax presents itself in two forms—the erysipelatous and carbuncular. In both varieties there is infiltration into the connective tissue under the skin and between the muscles, but in the latter the exudation is more or less circumscribed in the form of tumours under the skin, mucous membranes, and in the connective tissue. In both there is extreme venous congestion, and as a consequence hæmorrhagic extravasations are numerous and well-marked. The liver, kidneys, and lungs are congested, often greatly enlarged, and friable. But the most characteristic feature of the disease is the enlargement of the spleen,—the parenchyma of that organ being transformed into a violet or black fluid mass. The flesh is often flabby and dropsical, and rapidly passes into a state of putrefaction; while dropsical effusion may generally be detected between the lobes of fat surrounding the kidneys.

In anthracoid disease of the pig the chief symptoms are thirst, loss of appetite, rigours, hurried respiration, and

feverishness. If death does not ensue rapidly, as in the apoplectic form, the snout becomes of a leaden hue, and the ears, belly, and inner surface of the thighs become covered with red patches which deepen in colour. In the later stages of the disease, as in cattle, the temperature falls, the body becomes cold, and there is a muco-purulent discharge from the eyes. The carcase of a pig thus affected is livid, red, or mottled over most of the surface, the spleen is enlarged, and the flesh is sodden and darker in colour, while blood-coloured patches are generally found on the heart and intestines.

Sheep are more liable to the apoplectic form of the disease than other domesticated animals, and it especially attacks those that are well bred. In the majority of cases there are no apparent premonitory symptoms, the animal often falling down while grazing, and dying in convulsions within a few minutes. In other cases, which are not so rapid in their course, it is observed that the sheep is dull, carries its head low, does not eat, appears uneasy, and, if the herd is moving, drops behind. Its breathing is hurried, the pulse rapid, the conjunctival membrane congested, and the lower lip becomes marked with patches of a violet hue. When the disease is fully developed, the animal suffers from tremblings, so that it can no longer stand; and there is bloody discharge from the mouth, nostrils, and other passages. Sometimes there is œdema of the neck and flanks; and eventually convulsions set in. External tumours are rarely to be met with in sheep, and then mostly on the head, udder, or inside of thighs. The more common form of the localised disease is a diffused anthracoid erysipelas. In Scotland the splenic apoplexy of sheep is known as *braxy*. The flesh is very dark and often dropsical, and the spleen is increased in weight from two to six ounces.

The uncooked or imperfectly cooked flesh of animals

slaughtered for anthrax is extremely dangerous, and numerous widespread and fatal outbreaks of disease in man have been traced to the consumption of food of this description. But if well-cooked, it is said that accidents are rare. It need hardly be said, however, that, taking into consideration the great risk, the flesh of all animals slaughtered when suffering from the disease, or even when suspected to be infected, should be condemned.

(4.) *Foot-and-Mouth Disease.*—This disease is highly infectious, and attacks cattle, sheep, pigs, and other animals. It is characterised by an eruption of small vesicles in the mouth and on the tongue, sometimes extending to the nostrils. It also appears in the cleft and round the top of the hoof; while in cows, ewes, and sows the teats and udders are commonly affected. Quite recently Dr. Klein, in some researches carried on for the Local Government Board, has discovered crowds of *micrococci* in the vesicles, which he has been able to cultivate, and which, he maintains, is the cause of the disease. They appear in the vesicles in the shape of dumb-bells, or as chains, and by feeding sheep on a mixture which contained them, even after the twentieth cultivation, he has succeeded in producing the typical disease—viz. vesicles and ulceration of the feet. The vesicles, though small at first, often become large and confluent, and when they burst they leave bare red spots, which sometimes suppurate. Inside the mouth the vesicles burst soon after they are formed, and in cattle the saliva often becomes tinged with blood. When the limbs are affected the coronet becomes red and swollen, and the animal lame. Sometimes the hoof may be loosened or shed. Occasionally, and more particularly in sheep, the mouth and tongue are affected, or the feet may be very slightly affected without the appearance of vesicles. In severe

cases there is much fever, prostration, and thirst, while in sucking animals the disease frequently extends to the pharynx, larynx, and small intestines, and is sometimes of such severity as to induce typhoid symptoms. Except in severe cases, the flesh of animals slaughtered cannot be distinguished from the flesh of healthy animals, and may be passed, but the head, udders, and feet should always be rejected. If, however, the disease has been severe, and there are signs of inflammation or abscesses, or if the flesh is flabby, watery, ill-fed, and sets badly, it ought to be condemned.

Somewhat allied to foot-and-mouth disease, and occasionally mistaken for it, is contagious foot-rot of sheep, which is mainly distinguished from the former by the absence of mouth symptoms. It is in reality a chronic inflammation and ulceration of the soft parts of the feet, and it attacks more especially the purest breeds. It is characterised by lameness and suppuration, which often leads to shedding of the hoof. Except in cases when the inflammation extends to the carcase, and induces irritative fever and emaciation, the meat may be passed, provided it sets well, but the feet should always be condemned.

(5.) *Varioloid Disease.*—This disease in cattle, known as cow-pox, is generally so mild and rare that it only merits passing notice. After slight febrile disturbance, which often passes unnoticed, the udder is observed to be swollen near the teats, and in a few days small hard tumours about the size of a pea or bean appear on the teats and udder. These "pocks" gradually increase in size, and attain their maximum development on the eighth or tenth day, when they become purulent, and a crust forms which becomes detached from the eleventh to the fifteenth day. If used for vaccination, the vaccine matter is collected from the eighth to the tenth day before it becomes purulent, and it is at this stage that the disease

is most likely to be conveyed to the hands of milkers. Except in very rare instances, the disease runs a mild course.

The disease as it affects sheep is highly contagious and often extremely fatal. After two or three days of more or less severe febrile disturbance, an eruption, at first resembling flea-bites, appears on the inner aspect of the thighs, chest, and belly, extending over the whole body. Towards the fourth or fifth day the eruption becomes vesicular, and afterwards pustular. The eruption often extends to the mouth and nostrils, and the wool readily comes off. Except in the early stages of the disease, the flesh of slaughtered animals has a disagreeable odour, and even in suspected cases is altogether unfit for human food.

The common and fatal disease, sheep-scab, which is caused by a parasite, known as the *Psoroptes ovis,* usually disfigures the carcase so much that the flesh is not exposed for sale, and if exposed would be found to be flabby and emaciated. In swine the symptoms of variola are not unlike those of sheep-pox, and the eruption runs a similar course. The disease is highly contagious, and the flesh of slaughtered animals ought always to be condemned.

(6.) *Tuberculosis,* or consumption, more popularly known as *pearl disease* or the *grapes,* is a disease which specially affects cattle, and is most common among cows which are kept fastened up in crowded town cow-houses. The disease is slow and insidious in its onset, and may not be suspected until the animal loses in condition and begins to suffer from cough. The pearls or nodules, small at first, but gradually increasing in size, occur on the inside of the walls of the chest, the surface of the lungs, and, as the disease advances, the lungs themselves become affected, and eventually cavities are formed. On cutting open the nodules they will be found to consist of cheesy-

looking matter of the same consistence throughout, or softening towards the centre. In suspected cases, auscultation and percussion will reveal the true nature of the disease.

The flesh of animals slaughtered in the early stage of the disease may not present any features differing from those of sound meat, but in the more advanced stage it is pale, flabby, and poorly nourished, and should be condemned. The signs of pleuritic adhesions on the walls of the chest should be carefully looked for.

(7.) *Acute rheumatism* in cattle is commonly known as "joint-ill" or "joint-felon." The prominent symptoms are lameness and inability to rise, feverishness, and swelling of the joints. The serous fluid which is effused into the joints may subsequently become purulent, and abscesses are occasionally found in other parts. Frequently the meat becomes dropsical and should be condemned.

(8.) *Puerperal or milk-fever* not unfrequently attacks cows after calving, and if the animal is slaughtered when suffering from the disease the meat is certainly unfit for human food. The signs of recent parturition will be apparent, and the flesh will generally be found to be sodden and congested. If the slaughtering is due to some complication in calving or lambing, and the carcase is frankly submitted for inspection, it may be passed if the meat sets well and does not show any signs of congestion. The same remark would apply to accidents in general.

(9.) *Rot in Sheep.*—This disease is the most devastating of all diseases which attack sheep. Its essential cause is the presence in the bile-ducts of the liver of entozoa known as "flukes," small animals shaped like a sole, measuring from about an inch to an inch and a half in length, and when once seen can always be recognised.

These flukes attach themselves to the sides of the bile-ducts by means of suckers, and in the later stages of the disease are present in such large numbers that the ducts often become completely blocked up, and even burst, so that the substance of the liver becomes broken down. The prominent symptoms of the disease are dulness, sluggishness, and yellowness of the conjunctivæ; the wool drops off, the animal becomes emaciated, and as a rule dropsical. The flesh is found to be thin, watery, and flabby, and the tissues are more or less bile-stained. When the disease becomes pronounced, the flesh is undoubtedly unfit for human food, but the presence of a few flukes in the liver would not warrant the seizure of a carcase provided the meat looked healthy.

(10.) *Pig-typhoid or Hog-cholera.*—By some writers this disease is classified as identical with anthracoid disease, and, indeed, the symptoms bear a close resemblance to those already described under that heading. The premonitory symptoms are feverishness, restlessness, and rapidity of breathing, after which an eruption begins to appear on the skin, which may be red and patchy, when the disease is called "red soldier," or of a livid tint, when it is sometimes designated "blue soldier." The redness of the skin generally extends through the fat beneath to the muscular tissues, and the intestines often become marked with extravasations. Butchers, in order to disguise the character of the meat, sometimes rub the edges of the reddened fat with salt, but by scraping with a knife, or making a fresh incision, this attempt at deception may readily be detected. The lungs are generally found to be congested, or in parts more or less solidified by pneumonic exudation. When the skin eruption is well-marked, it is seldom that the meat is exposed for sale. The eruption sometimes bears a close resemblance to small-pox, pus being secreted and followed by the formation of

crusts. The flesh of all pigs, whether suffering or suspected to be suffering from this disease should be condemned.

(11.) *Quinsy,* or "strangles," is a disease which sometimes attacks pigs. It is characterised by sore-throat and swelling in the neck, which may extend into the fore quarters. The premonitory symptoms are laboured breathing, refusal of food, and swelling about the throat, which looks red or livid. The flesh is unfit for human food.

(12.) *Trichiniasis* or *Trichinosis* is a disease which infests a number of animals, but the chief interest attaching to it is the fact that it is a disease to which pigs are liable, and by eating diseased pork is transmissible to man. The essential cause of the disease is the presence of a parasite known as the *Trichina spiralis* in the muscular tissue of the pig. These parasites are found to exist in three conditions in the animal body—as intestinal, embryonic, or muscular trichinæ. During the period of reproductive or genital activity they inhabit the intestines, and it would appear that in their course of migration they penetrate the intestinal walls, fall into the abdominal cavity, and are discovered earliest in the muscles which enclose the cavity, viz., the diaphragm and abdominal muscles. Other muscles become subsequently infested—the intercostals, muscles of the neck, head, and back, and last of all the muscles of the limbs and tail. In these different regions of the muscular system they continue their development, become at length encysted, and then remain perfectly stationary. Their further development depends upon whether or not the trichinosed flesh is eaten in an uncooked or imperfectly cooked state, when they again pass through similar stages in the newly infested animal, that is to say, breed in the intestines and migrate to the muscular tissues, and in this way they infest man.

In searching for trichinæ in pork the muscles most liable to be infested should be selected, such as the diaphragm, masticatory muscles near their insertion, or intercostal muscles, and the aid of a powerful pocket-lens or microscope is necessary. But without the microscope the eye may discern a paleness and œdematous condition of the flesh if the trichinæ are very numerous, while the flesh itself presents a speckled appearance. These small white specks are the spherical or oval cysts in which the parasites are coiled up, and sometimes they feel gritty, owing to the presence of carbonate of lime. In order to examine them microscopically, a very thin shaving of the flesh in the direction of the muscular fibrillæ should be placed on a glass slip, and soaked in a solution of liquor potassa (one to eight or ten of water), but for only a few minutes. The section should then be teased out with needles, protected by a covering glass, and placed in the field of a microscope with a magnifying power of 50 to 200 diameters. If the capsule is thick and opaque, owing to the presence of carbonate of lime, a drop of weak solution of hydrochloric acid will render it transparent; and should a little fat obstruct the view, a drop of ether or benzin will remove it. The fully-developed trichinæ, in their genital stage, must be looked for in the small intestines, more particularly in the layer of mucus covering the lining membrane of the duodenum. In the migratory stage of the undeveloped trichinæ, and before they become encysted, a high power is necessary for their detection. Swine infested with the disease may not present any noticeable symptoms during life. The flesh should invariably be condemned.

(13.) *Measles in the Pig.*—This disease, like the preceding, is due to a parasite or entozoon, in the form of a bladder-worm, known as the *Cysticercus cellulosus.* It is much larger than the *Trichina spiralis,* and is de-

veloped from the ova of the human tape-worm (*Tænia solium*), which are expelled from the intestine along with the fæces. These ova are swallowed by the pig when it devours infested fæces, and the embryos which they contain are developed into hydatids. Each embryo is provided with six hooklets, and soon after being introduced into the interior of its host, it commences to penetrate the tissues in its immediate neighbourhood, until it has reached a favourable position, when it assumes the hydatid or bladder form. This it maintains permanently, unless it is transferred by the meat which it infests to the intestinal canal of man, when it develops into the fully matured tape-worm. The cysticercus is contained in an egg-shaped bladder, varying in size from an eighth to three-eighths of an inch in length, and surrounded by fluid. Unlike the cysts of the *Trichina spiralis*, which are embedded in the substance of the muscular fibrillæ, these bladders are found between the muscular fibres, and often on the surface of the muscles. To examine one of these bladders, it should be put on a glass-slip and incised, when, with the aid of a good pocket-lens, the worm will be found curled up in the cavity. It is about one-third of an inch in its longest diameter, or varying from the size of a pea to that of a cherry, and in its retracted state it is somewhat oval or elliptical. In order to examine the head it is necessary to extract it from its cavity or *receptaculum* with fine needles, when it is found to be square-shaped if viewed from above, and conical when viewed in profile. It is furnished with four muscular suckers, and the small depression at the apex of the head is surrounded with hooklets, varying from twenty-four to twenty-eight in number, which, when once seen, cannot be mistaken. The muscles of the tongue, neck, and shoulders are most liable to become infested, and next in order the intercostal muscles, and

those of the lumbar region, loins, and thighs, while sometimes hydatids may be detected in large numbers in the muscular substance of the heart, and in the liver, lungs, and brain.

The disease more particularly affects young pigs, and those verging on maturity. The symptoms are very variable, and in mild cases the disease may not be suspected. If suspected, it is usual to examine the under surface of the tongue, when frequently the little bladders may be felt or seen. In the more advanced stage of the disease they may be detected under the tail, round the ears, or in the conjunctival membrane of the eye. When the disease becomes general and severe there is loss of appetite, the animal becomes stiff and awkward in its movements, and swellings are more particularly observed around the withers. Pork infested with these parasites is called measly, owing to the characteristic appearance of the flesh on section. When the flesh is dried or salted, the cysts shrink, and in order to detect them a small slice should be steeped in water. The flesh of measled pigs should not be used as food, even though the hydatids may apparently be few in number.

Measles in the ox, like pig-measles, is also parasitic, the entozoon being the larval cestode of the *Tænia medio-canellata*, which is a human tape-worm infesting the small intestine. The symptoms of the disease, the development of the entozoon, and the appearance of the infested flesh and cysts, so closely resemble those already described respecting the *Cysticercus cellulosus* in the pig, that no further description is necessary. The meat should be condemned.

There is another parasite having for its habitat the lungs of sheep or oxen which may be mentioned here. It is known as the *filaria*, a thin worm from half an inch to three inches in length. It is not a common disease,

and unless it induces severe inflammation of the lungs, fever, and emaciation, the meat may be passed.

Immature veal or lamb should be condemned as unfit for food if the animals have been born prematurely, or have died during birth, when the flesh is known as "slink meat." It should also be remembered that the flesh of animals may become unwholesome owing to the animals having been accidently or maliciously poisoned, and in these cases the meat may look perfectly healthy provided the animal has been slaughtered. In suspicious cases of this description the stomach and intestines should be carefully examined for traces of inflammation, and the first stomach, for pieces of meadow-saffron, bryony, or yew-leaves, etc. The flesh of animals slaughtered on account of accident may be passed, provided that the accident has not led to severe febrile disturbance, and the meat sets well; but if the animal has died from accident, the meat should be condemned, because the carcase has not been bled. The flesh is dark in colour, full of blood, sets badly, and rapidly decomposes.

2. *Butcher Meat.*—A healthy carcase should be well-bled, no part of it being dark or speckled, bruised or bile-stained. The meat should set well, so soon as the carcase cools, and should not present an emaciated appearance. It should not be flabby or pit on pressure, nor should it crackle, because this would indicate the presence of air.

When a carcase is inspected, the offal should be inspected too, and it should always arouse suspicion if the butcher says he has destroyed or thrown away the offal and cannot produce it. In oxen and sheep the offal consists of the head, hide, feet, and all the internal organs with the exception of the kidneys; but in pigs the head, feet, and skin form part of the carcase. In examining the offal it should be noted that the skin is free from

sores or pustules, that there are no signs of bruising, and that the hoofs are healthy-looking and firmly attached to the feet. The mouth and tongue should be free from patches or ulcers. The internal lining of the stomach should present no signs of inflammation, and should have no smell of physic, while the intestines should have a smooth uninflamed lining, and be free from ulcers or patches. The liver should not be friable, be of a rich brown colour, and free from abscesses or flukes. The spleen should be a gray colour outside, thin, long, and sharp (not rounded) at the edges, and on section should be dark inside. The lungs should be of a pink, bright colour, and spongy, and portions cut off should float in water. They should also be free from cavities, pus, or worms, and their surfaces should present no signs of inflammatory patches or recent pleuritic adhesions.

In order to acquire a practical knowledge of the healthy appearance of sound butcher-meat, whether in carcase or cut up for sale, the sanitary official should make repeated inspections of the contents of a butcher's shop whose trade is above suspicion, and he should also visit the slaughter-house and make careful examination of the various parts of the offal. His knowledge of unsound meat and diseased offal would be most readily gained by accompanying a meat-inspector on his rounds in one of our large towns.

The characters of good meat may be enumerated as follows :—

(1.) On section it should present a marbled appearance from intermixture of streaks of fat with muscle. This shows that the animal has been well fed.

(2.) The colour of the muscle should neither be too pale nor too dark. If pale and moist, it indicates that the animal was young or diseased; and if dark or livid, it shows that in all probability the animal was not

slaughtered, but died with the blood in it. The muscles in pork, veal, and lamb are pale.

(3.) Both muscle and fat should be firm to the touch, not wet or sodden. The latter should be free from hæmorrhagic points, and the suet fat should be hard and white.

(4.) Any juice exuding from the meat should be small in quantity, be of a reddish tint, and give a distinctly acid reaction to test-paper. Good meat should dry on the surface after standing a day or two. The juice of bad meat is alkaline or neutral.

(5.) The muscular fasciculi should not be large and coarse, nor should there be any mucilaginous or purulent-looking fluid to be detected in the intermuscular cellular tissue.

(6.) The odour should be slight, and not by any means disagreeable. An unpleasant odour indicates commencing putrefactive change, or that the meat is diseased. By chopping a portion of the meat into small pieces, and afterwards drenching it with warm water, any unpleasantness of odour will be more readily detected. Another good plan is to thrust a long clean knife or skewer into the flesh and smell it after withdrawal.

(7.) When meat is salted, the brine should not become sour or offensive.

When meat becomes bad through partial decomposition, owing to its having been kept too long, its chief characteristic is an offensive or putrid smell. The external surface is pale or livid, and, at a later stage, greenish. The meat is soft, tears easily, and loses its elasticity, and the juice is acid or neutral. The flesh of animals which have not been slaughtered, or only slaughtered when in a dying state, is dark in colour and often purple, full of blood, sets badly, and readily decomposes. Diseased meat is usually sodden and flabby,

often emaciated, with the fat discoloured or gelatinous-looking, and the smell unpleasant or sickly. The ribs should always be examined for pleuritic adhesions, and in cases of suspected dropping after calving the udders and peritoneal lining should be carefully scrutinised, while in all cases the flanks should be looked to, because it is generally in these parts that putrefactive change first sets in. When the offal can be obtained for inspection the various organs should be minutely examined, but it is seldom that the butcher who wishes to sell diseased meat leaves any of them exposed to the risk of detection, and this, as already said, should always arouse suspicion. If parasitic disease is suspected, the muscular fibre should be examined under the microscope. Cysticerci, though generally visible to the naked eye, can be accurately detected under a low power or by means of a good pocket-lens, and the hooklets should be always seen. In searching for trichinæ, it should be remembered, as previously stated, that the parts most likely to be infested are the diaphragm, the intercostal muscles, and the muscles of the jaw. A low power of 50 to 100 diameters will generally be found to be sufficient. When meat is seized, very often the defence is set up that it is intended for dogs' meat; but if it is found in the butcher's shop, or dressed in the usual way, there is generally very little difficulty in obtaining a conviction. In cases of this description which are brought before the magistrates, and likely to be strongly contested, it is always advisable, if possible, to get extraneous evidence concerning the previous history of the animal, and the price at which it was sold, and in country districts this can often be ascertained.

There is no doubt that large quantities of diseased meat are used up in the making of sausages, and instances of serious illness arising from food of this description are not at all uncommon, especially where the sausages are

not well cooked. Bad-smelling sausages, or sausages which have a nauseous or putrid taste, an acid reaction, or a soft consistence in the interior, are highly dangerous and should always be condemned. Tinned meats too, and so-called potted meats, are liable to putrefactive change, and should therefore be carefully examined, particularly as regards smell and taste, before being used.

Before leaving this part of the subject, I may mention that it is the practice in the City of London to condemn the flesh of all animals infected with parasitic disease, such as measles, flukes, etc.; of animals that may have been suffering from acute, febrile, or wasting diseases; and of those which have died from natural causes or by accident; as well as all meat tainted by physic, or in a high state of putrefaction. It is also the practice to condemn the flesh of any animal which has been killed immediately before, during, or immediately after parturition, on the presumable grounds that an animal would not be slaughtered under such circumstances unless, from some cause or other, death appeared to be impending.

3. *Poultry.*—Good poultry should be fairly well-fed, firm to the touch, and present a pink or yellowish colour, while the smell should be fresh, and not unpleasant. Stale poultry becomes bluish in colour, often green over the crop and abdomen, has a disagreeable odour, and the skin breaks readily.

The disease which is most likely to render the flesh of poultry unfit for human food is fowl-cholera, which may affect geese, ducks, turkeys, and pigeons, as well as domestic fowls. It is seldom, however, that any birds so affected are exposed for sale. The symptoms of fowl-cholera when the disease does not become rapidly fatal are briefly these :—The feathers present a bristling appearance, the comb becomes limp and livid, the wings drop, the bird loses appetite and drinks much, and becomes

swaying or dragging in its gait. Eventually diarrhœa sets in, muco-purulent at first, and later on streaked with blood. If the bird dies or is killed and prepared for the market, the flesh is found to be somewhat redder than usual, the substance of the liver more friable, and the interior of the intestines marked with extravasations. Decomposition sets in rapidly.

4. *Game.*—According to modern ideas game must be in a state of decomposition, or what is called more or less "high," before it is considered to be fit for the table. It is therefore very difficult to decide when such a stage of decomposition has been reached as would warrant its seizure. But when the flesh becomes putrid, and the odour offensive, there is no doubt that it is unwholesome and should be condemned.

5. *Fish.*—Fresh fish should be firm, and without any disagreeable odour. If the whole fish is held out horizontally there should be very little drooping of the tail. The fish usually hawked about the streets is generally more or less limp and soft, and if it is found to be offensive as well, there is no doubt that decomposition has set in, and that it is unwholesome. But fish which is apparently healthy often gives rise to serious symptoms, such as vomiting, diarrhœa, and prostration. Herrings, pilchards, and other kinds of fish may occasionally induce symptoms of poisoning, and it is not at all an uncommon occurrence to find a prickly rash following the eating of healthy shell-fish.

6. *Fruit and Vegetables* may become unwholesome from decay or disease, and the principal indications are softening, discoloration, or mouldiness. Unripe food, such as windfall apples, are certainly unwholesome, unless well-cooked. Good potatoes should be of fair size, give no indications of disease on section, be firm to the touch, and when cooked should not be close or watery. Potatoes

which have been exposed to severe frost become soft and watery, and are rendered unfit for food.

Tinned fruits and vegetables, like tinned meats, are generally more or less contaminated with tin; but as the metal is not poisonous except in large doses, the small amount which is generally found to be present is not injurious. Green peas, French beans, and other vegetables, such as pickles, are frequently adulterated with copper to retain the fresh green colour. This adulteration is no doubt injurious, and may readily be detected by leaving the clean blade of a knife in the liquor for a short time, when the copper will become deposited on the blade.

7. *Corn.*—This includes wheat, barley, oats, rye, rice, and maize. Smut, bunt, and ergot are the most common diseases affecting corn in this country, ergot especially affecting rye; bunt, wheat; and smut, barley and oats. They are all of them vegetable parasites, distinguishable under the microscope. Stored corn may become infested with an insect known as the weevil or by *acari*, and if stored when damp may become unwholesome owing to fermentive changes.

8. *Flour.*—What is called good household flour or "seconds" should contain very little bran, be quite white, or only slightly tinged with yellow, and should give no acidity or musty flavour to the taste. It should not be lumpy or gritty to the touch, nor should it yield any odour of mouldiness to the sense of smell. When made into a paste with a little water, the dough should be coherent and stringy, and even in the dry state it should cohere when compressed.

The amount of gluten can be ascertained by washing carefully a known quantity of flour, made first into a rather stiff dough, until the water comes off quite clear. The gluten, when baked or dried, should be clean-looking, and should weigh at least 8 per cent of the quantity of

flour taken for examination. A good flour will yield 10 to 12 per cent. Bad flour gives a dirty-looking gluten, which is deficient in cohesion, and cannot be drawn out into long threads.

Flour is sometimes adulterated with barley-meal, maize, rice, potato-starch, etc. Samples of doubtful quality should therefore be examined microscopically. *Fungi, vibriones,* and the *Acarus farinæ* are detected in flour which is undergoing putrefactive change.

Adulterations with mineral substances, such as chalk, gypsum, or carbonate of magnesia, are best detected by burning a weighed quantity of flour down to the ash, which should not exceed 2 per cent.

What is called whole meal should always be well-ground, and should give no acid or mouldy taste.

Oatmeal is generally roughly ground, and contains a fair amount of envelope freed from the husk. If husks are present the probability is that the meal has been adulterated with barley. The starch should not be discoloured, and the meal itself should be agreeable to the palate. If the meal looks suspicious, it should be examined microscopically.

9. *Bread.*—The crust should be well-baked, not burnt. The crumb should not be flaky or sodden, but regularly permeated with small cavities. The taste and smell should both be agreeable, and free from acidity. Unless there is a considerable quantity of bran in the flour, as in whole-meal bread, the colour should be white, not dark or dirty-looking. Bread is aerated with leaven or yeast by kneading the flour with water charged with carbonic acid, or by mixing it with baking powders. Unleavened bread, and many kinds of cakes and biscuits are not aerated.

Bread may become heavy and sodden owing to bad flour, bad yeast, or a gummy mixture of ground-rice. It may become sour owing to the quality of the flour, or to

excess of fermentation, or it may become mouldy owing to its having been kept too long, or stored in a damp place. Biscuits, and especially ship biscuits, are often attacked by weevils.

Good flour, well-baked, yields about 136 lbs. of bread per 100 lbs. of flour, and adulteration is chiefly directed to increase this ratio by making the gluten hard, and the bread more retentive of water. Ordinarily a 4-lb. loaf loses about $1\frac{1}{2}$ oz. in twenty-four hours, and about 5 oz. in forty-eight hours. Wheaten bread is sometimes adulterated with barley-meal, oatmeal, or boiled rice, and in order to improve its appearance when it is made from inferior, damaged, or adulterated flour, a small quantity of alum is added, generally less than 50 grs. to the 4-lb. loaf. The readiest test for alum in bread is the test known as the log-wood test. A tincture of log-wood is made by digesting 5 grammes of log-wood chips in 100 cubic centimetres of strong alcohol, and a solution of ammonia is made by dissolving 15 grammes of carbonate of ammonia in 100 cubic centimetres of distilled water. A teaspoonful of the tincture of log-wood, and the same quantity of the ammonia solution, are mixed with a wine-glassful of water, and in this mixture a small crumb of the bread to be tested is allowed to remain for about five minutes. The bread is then removed, and dried at a gentle heat, when, if much alum is present, the bread dries of a dark blue colour; if only a little, the colour is lavender; and if no alum be present, the bread dries of a dirty brown colour.

10. *Milk.*—Pure cow's milk, when placed in a tall narrow glass vessel, should be perfectly opaque, of a full white colour, free from deposit, and should yield from 6 to 12 per cent of cream by volume. When boiled it should not change in appearance, and when allowed to stand for some time there should be no deposit. As it

is frequently adulterated with water, the specific gravity is an approximate test of the quality, and hence the use of the lactometer. The specific gravity varies from 1026 to 1035; if it falls below 1026 it shows that the milk is either very poor, or that a certain amount of water has been added. The following table by Dr. Letheby indicates approximately the amount of water adulteration according to the specific gravity and percentage of cream :—

	Specific Gravity.	Percentage volume of cream.	Specific Gravity when skimmed.
Genuine milk	1030	12·0	1032
Do. with 10 per cent water	1027	10·5	1029
Do. ,, 20 ,, ,,	1024	8·5	1026
Do. ,, 30 ,, ,,	1021	6·0	1023
Do. ,, 40 ,, ,,	1018	5·0	1019
Do. ,, 50 ,, ,,	1015	4·5	1016

After the milk has been allowed to stand from four to eight hours, the cream rises, and the remainder of the milk becomes less opaque. The quantity of cream which separates varies from 6 to 12 per cent—a small percentage of cream being always retained by the milk, even although it is allowed to stand for twenty-four hours. The milk which is milked last at a single milking is called the "strippings," and is much richer in cream than the milk first milked, called the "fore-milk." Milk, too, varies very much in quality and quantity according to the breed of the cow, her age, health, number of pregnancies, the period which has elapsed since calving, and the nature of the food upon which she is fed. About twelve quarts is the daily average yield, but immediately after calving the yield may be double this quantity. The first milk obtained after calving is called *colostrum*, popularly known as "beestings." It is of a high specific gravity—about 1050, of a rich yellow colour, clots very readily, and has a taste somewhat like beaten eggs.

Asses' milk and goats' milk, both of which are sometimes used for food, resemble cows' milk in composition, but the relative proportion of the constituents varies appreciably, the former having a lower specific gravity than cows' milk, and the latter a higher.

Milk is highly absorbent, and therefore becomes readily tainted with noxious or offensive vapours or smells, such as exhalations from middens or drains, or the foul, close air of a dirty-kept dairy or pantry. It then presents the taste and smell of the absorbed impurity, rapidly decomposes, and is certainly unfit for human food. Very probably it is in this way that such fungi as the *Oidium lactis* are generated, and it is well known that milk so affected has frequently been the cause of gastric irritation and vomiting. Some maintain that the milk of cows which have eaten poisonous herbs, feed on sewaged grass, or drink polluted water, may be rendered unwholesome, but there is no reliable evidence in support of this view. Indeed, so far as feeding on sewaged grass is concerned, there is now an overwhelming amount of evidence to the contrary, and I know as a matter of fact that there are large quantities of milk sold daily, in and around Leamington, obtained from cows fed exclusively on this grass during the summer, and that on every occasion on which samples have been analysed, it has been found to be richly flavoured and of excellent quality. It may also be noted that several analysts have made repeated experiments with the butter, and have found that it possesses none of those tendencies to putrefactive change which have been gratuitously ascribed to it.

But apart from becoming tainted when exposed to foul effluvia, milk often becomes unwholesome from keeping, especially in warm weather. It takes up oxygen from the air, and gives off carbonic acid gas; lactic acid

is then formed from the lactin, and the milk curdles and becomes sour.

Milk from diseased animals, or from animals suspected of disease, should be examined microscopically. The normal constituents of milk, as seen under the microscope, consist of round oil globules, enveloped in a cyst, and scattered epithelial cells; but in milk obtained from diseased animals, blood, pus cells, and aggregated granules may often be detected, and sometimes casts of the lacteal tubes, while bacteria and small oval and round cells are not at all uncommon.

Disease in the cow often arrests, and almost always diminishes, the flow of milk. In anthrax and anthracoid diseases it is thick, of a bad colour, contains pus or blood cells, and rapidly decomposes. Milk from cows suffering from pleuro-pneumonia, garget or inflammation of udder, foot-and-mouth disease, tuberculosis, or, indeed, any acute febrile disorder, should be condemned as unfit for food. But the great danger always is that milk of this description is not unfrequently mixed with large quantities of good milk, and so may escape detection.

Then again, milk may become infected with the germs of animal disease; as from the mouth discharge of a neighbouring cow suffering from foot-and-mouth disease, or, as has occasionally happened, from the nasal discharge of a horse suffering from strangles, put up in the same outhouse. I have reason to believe, too, that symptoms of a diphtheritic nature have been induced by using milk obtained from a cow which the calf is allowed to suckle occasionally, when the calf itself was suffering from throat symptoms.

But the most severe outbreaks of disease arising from tainted milk, as will be shown in the following section, have been caused by admixture with polluted water, or from absorbing specific morbid germs. Many outbreaks

of scarlatina have arisen through the dairyman or some members of his family having the disease, or sometimes owing to a delivery-can not having been thoroughly washed after having been brought from an infected house. Diphtheria too may be spread in the same way, and there is every reason to believe that if the milker is suffering from ulcerated throat of a diphtheritic nature, there is great danger of the milk becoming infected, through the breath impinging on it as it flows into the can. The only safeguard against all these dangers is boiling the milk.

In most cases of falsification milk is watered or creamed, or both watered and creamed. Watering is detected by a lowering of the specific gravity, and a diminished percentage of cream; but when creaming alone is resorted to, the specific gravity is raised and the percentage of cream diminished. When both are resorted to, the specific gravity may be normal, but the percentage of cream is, of course, always lessened. When milk has been falsified in this way, other substances, such as treacle, salt, turmeric, carbonate of soda, etc., have sometimes been added to improve the flavour and appearance; but, generally speaking, the use of a graduated vessel to determine the percentage of cream, and testing the specific gravity, will enable one to give a reliable opinion as to whether the milk has been tampered with or not. Suspicious samples should be sent to the public analyst for analysis.

11. *Butter.*—Butter should give no unpleasant or rancid taste. Adulteration with water or animal fats is best detected by melting the butter in a test-tube; the water, salt, or other substances remaining at the bottom. After separation of the casein by melting, good butter is entirely soluble in ether at 65° Fahr., while the fat of beef or mutton dissolves with great difficulty, and leaves

a deposit. Adulteration with potato or other starch can be at once detected by iodine. Good butter, when melted, should yield a clear-looking oil, with little deposit of water or other substance.

12. *Cheese.*—The quality of cheese is determined by the taste and consistence. Inferior cheeses are often soft and leathery, owing to the amount of water which they contain. Starch, which is sometimes added to increase the weight, may be detected by iodine.

13. *Eggs.*—An average-sized egg weighs about 2 oz. avoir. Fresh eggs, when looked through, are more transparent at the centre; stale ones, at the top. In a solution of 1 of salt to 10 of water, good eggs sink, while the stale ones float.

14. *Tea.*—The *bloom* or *glaze* of black and green tea is generally artificial. In the case of black tea, it sometimes consists of a coating of black-lead; and in that of green tea, it is usually a mixture of Prussian blue, turmeric, and China clay. Both kinds of adulteration are detected by shaking the leaves in cold water, straining through muslin, and afterwards examining the deposit. Inferior mixtures, such as Maloo mixture, Moning congou, Pekoe siftings, etc., are largely imported into this country, and consist of exhausted tea-leaves, leaves of other plants, iron-filings, etc., with only a little good tea.

Good tea should yield a pleasant aroma, alike in the dry state and when infused in boiling water, and the flavour of the infusion should be agreeable. The test for tea of the first quality is to put a small quantity in a cup, pour water at the boiling point on it, taste it for its flavour, then allow it to stand until it cools, when it should throw up what is called a cream. The leaves, when spread out, should be small, serrated, elongated, and liver-coloured. If the tea is suspicious, the infused leaves should be spread out and carefully

scrutinised, and any powdery deposit examined under the microscope.

15. *Coffee.*—The principal adulteration of coffee is chicory. The adulteration may be detected either by microscopic examination or by sprinkling a portion of the suspected sample on the surface of water, when the coffee will float and the chicory sink. The presence of chicory is also indicated, if, on opening a packet of coffee, the contents are found to be caked, or show any signs of caking.

Amongst other articles of food or drink which are liable to adulteration may be mentioned cocoa, mustard, pepper, confections, beer, wine, and spirits; but without entering further into this part of the subject, it will be sufficient to point out that any article of food or drink, or any drug which is supposed to be adulterated, should be submitted to a public analyst, on whose report proceedings may be taken under the provisions of the "Sale of Food and Drugs Act, 1875."

Section VII.—The Effects of Insufficient or Unwholesome Food on Public Health.

1. The minor effects of insufficient food are generally so intimately associated with those of other causes of disease, that it is impossible to estimate, with any approach to accuracy, their separate influence on public health.

Only those who have threaded the dingy streets and dirty courts of our large towns can form any adequate conception of the wide-spread suffering and disease which follow in the wake of actual want. Clothing and fuel even scantier than the food, overcrowding with all its attendant evils, sanitary arrangements of the worst description, rickety floors and reeking walls, all contribute to the heavy load of misery which the destitute

have to bear. Indeed, as regards the civil population, the history of relapsing fever is almost exclusively a history of the ravages of disease arising from destitution, and the famines of the present century, especially those of 1817 and 1847, need only be referred to as evidence on this point. There is no doubt too that the large mortality among infants and young children is in great measure due to insufficient food, and at all ages there are crowds who from sheer want fall ready victims to some form of adynamic disease.

2. *Unwholesome Food.*—Although much of the apparent immunity from disease enjoyed by the large numbers who unwittingly indulge in unwholesome food at times is to be attributed to the antiseptic power of good cooking, there are also many instances on record in which food of the most putrid description is devoured without producing any ill effects. Thus, according to the late Sir Robert Christison, there are whole tribes of savages who eat with impunity rancid oil, putrid blubber, and stinking offal; and in this country game is not considered to be in a fit state for the epicure's table until it is undergoing rapid putrefactive change. Admitting all this, however, there is abundant evidence to prove that serious consequences resulting from the use of unsound meat are of frequent occurrence, and in all probability a large proportion of cases of obscure disease owe their origin to the same cause. Moreover, it is but only logical to conclude, from general principles, that, as all diseases must affect the composition of animal flesh, and as active putrefactive change must at all events deteriorate its nutritive value, it is of the utmost importance to health that these substances should be obtained in as sound a condition as possible.

The following is a brief abstract of the more important facts connected with this part of the subject:—

(1.) *Putrid Meat.*—On the whole, this may be said to be wasteful rather than positively injurious, but there are numerous cases recorded in which it has produced serious disease. Vomiting, diarrhœa, and low fever of a typhoidal type, are the chief symptoms. Putrid sausages are especially dangerous. According to an official return, it appears that in Wurtemberg alone, during the last fifty years, there have been 400 cases of poisoning from German sausages, and of these 140 were fatal.

(2.) *Diseased Meat.*—Here, again, the evidence is of the same conflicting character. According to Dr. Letheby, enormous quantities of the flesh of animals that died of rinderpest in 1863, and more recently of pleuro-pneumonia, have been sent to the London market, sold, and eaten, without having produced any tangible ill effects. It is also well known that Scotch shepherds indulge largely in *braxy*, or diseased mutton, with apparent impunity; and, according to M. Decroix, the whole of the inhabitants of Paris would have suffered during the late siege if diseased meat were to any extent dangerous.

In the face of such evidence as this, it really becomes a question of public importance whether the flesh of *all* animals diseased should be condemned. As a matter of fact, about one-fifth of the meat at one time sold in the London market, according to Professor Gamgee, was of this description; and it has been urged that, if it were sold under its true character, and proper precautions were taken with regard to selection and cooking, the ill effects which sometimes attend its use might not occur. It has been urged, too, that though such meat would be of inferior quality, it would be much cheaper, and thus come within the reach of many who are sorely in want of animal flesh, but cannot buy it at its present price. As it is, however, the butcher sells it under a fictitious character,

and it is therefore the duty of the health officer to condemn it.

In the numerous cases of illness which have been attributed to the use of diseased meat, the symptoms are very similar to those occasioned by the use of putrid meat. The exceptional symptoms apply chiefly to the transmission of specific or parasitic disease. Thus numerous instances have been recorded in which persons have been seized with malignant pustule after eating the meat of animals suffering from anthrax; and Dr. Creighton, in a paper read before the International Medical Congress, 1881, has aroused grave doubts as to whether tuberculosis may not be transmitted to man through eating the flesh of animals suffering from this disease. Sausages and pork-pies have been frequently known to induce symptoms of irritant poisoning, and this is not to be wondered at, considering the vast quantities of diseased meat that are used up in this way. As regards the development of parasitic disease, reference has already been made in the previous section to the fact that the *Cysticercus cellulosus* in measly pork produces the *Tænia solium*, and that of the ox or cow the *Tænia mediocanellata*. The *trichina* disease, again, which was so prevalent in Germany and elsewhere a few years ago, is due to the *Trichina spiralis* in the pig; while the *ecchinoccus* disease, so common in Iceland, owes its origin to the flesh of sheep and cattle which have become infested by the tænia of the dog. It appears that all these parasites are destroyed if the meat is thoroughly cooked before eating.

One of the most remarkable outbreaks which have recently been investigated in connection with diseased meat occurred among persons attending the sale of the late Duke of Portland's effects at Wellbeck, Notts, in June 1880. Dr. Ballard, who was appointed to conduct

the inquiry, found that as many as seventy-two persons were attacked with intense diarrhœa, with febrile symptoms, after partaking of luncheon, and four of the cases proved fatal. From among the various articles of food or drink which were partaken of at the luncheon, he was able to exclude everything except the ham and beef as being in any way implicated in the production of the disease, while other considerations suggested the hams or some of them as being most probably at fault. Microscopical examination of the provisions then showed that the hams were infested not with trichinæ, but with a special *bacillus* not previously known; while numerous specimens of this bacillus were found in the kidney of one of the fatal cases on *post-mortem* examination. Further, Dr. Klein, on feeding small animals on portions of the suspected ham, or inoculating them with it, developed in them similar symptoms to those from which the infected persons had suffered, and many of them died with acute inflammatory disease of one organ or another; while bacilli, taken from two of the hams and cultivated in the white of egg, produced on inoculation similar results. Another outbreak of much the same character was investigated by Dr. Ballard in February 1881, and occurred at Nottingham. In this outbreak it was found that after eating baked pork, fifteen persons were attacked, and one died. In this instance no specimen of the meat could be obtained, but numerous bacilli were found in the body of the patient who had died. (*Report of the Medical Officer of the Local Government Board*, 1881.)

(3.) Some kinds of fish, especially in warm weather and in hot climates, have been known to produce very severe symptoms. Thus cases of acute urticaria, with swelling of the tongue, fauces, and eyelids, are frequently due to eating lobsters, crabs, or shell-fish; while gastro-intestinal irritation, sometimes of almost choleraic inten-

sity, is by no means a rare consequence of eating putrid fish of any kind. The disease known by the Spanish name of *siguatera* is of this description, and is common amongst the crews of vessels doing duty in the tropics when they partake of fish caught at the various stations as a change from the ordinary diet of the ship.

(4.) As regards unwholesome vegetable food, it may be said that all food of this description which has become mouldy is dangerous. On the Continent, the ergot of rye has been productive of serious epidemics, and in this country alarming symptoms have frequently followed the use of flour which contains the ground seeds of *Lolium temulentum,* or darnel.

In connection with the subject of unsound food, special notice should be taken of the spread of disease through the agency of milk. And, first, it has to be noted that the milk of animals suffering from disease, as from foot-and-mouth disease, though no doubt frequently used with impunity, sometimes produces aphthous ulceration of the mouth and gums, with swelling of the tongue and great fœtor of the breath. Dr. Thorne reports an outbreak of this nature (see *Twelfth Report of the Medical Officer of Privy Council*), and I have myself witnessed a few well-marked cases of this description. Dr. Paine, Medical Officer of Health, Cardiff, found that concurrently with an epidemic of foot-and-mouth disease in the town, a severe form of sore-throat became prevalent amongst children in the infected neighbourhood, and microscopic examination of the milk led him to believe that this was the cause. (*Sanitary Record*, 1879.)

Although it may be quite true that the milk of diseased cows has often been used without producing any appreciable ill effects, still there is always a certain amount of risk, and on that account it cannot be too strongly insisted on that all milk of the kind, or indeed

any milk yielded by a cow suffering from any form of disease, should be condemned as unfit for human food. In the Western States of America the milk of cows affected with "the trembles" has frequently been known to cause severe gastric symptoms amongst children, accompanied by great weakness and lowering of the temperature.

But, as has already been pointed out, the great danger attaching to milk as a carrier of disease depends upon its remarkable powers of absorption and the rapid fermentive or zymotic changes which it undergoes when it becomes mixed with putrefying matter, or tainted with disease-germs. If, for example, milk is exposed to noxious vapours of any kind, it will very soon taste of them; and in like manner, if it be kept in any close or badly-ventilated place, where foul odours are perceptible, it will soon become tainted and unfit for use. Very probably, it is in this way that such fungi as the *Oidium lactis*, described by Fuchs, Mosler, and Hessling, are generated, and it is well known that milk so affected has frequently been the cause of gastric irritation and sharp attacks of vomiting. Moreover, there can be no doubt that much of the infantile diarrhœa, which proves specially fatal during the summer and autumn months, is due to milk, which either becomes tainted in this way, or by being put into feeding-bottles which are seldom or never properly cleaned. Indeed, there are so many unseen dangers in the use of milk, especially amongst careless and filthy people, that, to ensure safety, it should always be boiled during warm weather, and particularly in districts where foot-and-mouth disease is prevalent. Milk should never be stored in sculleries or larders, or in vessels made of lead or zinc; in the latter case it speedily absorbs salts of the metal, and becomes poisonous.

As regards the spread of specific disease, there is now an overwhelming amount of evidence which proves, beyond dispute, that milk is largely instrumental in propagating scarlatina and enteric fever; and amongst the outbreaks first published may be mentioned one of scarlatina, in St. Andrews, by the late Professor Bell in 1870; another during the same year in Penrith, by Dr. Taylor; and the well-known outbreak of enteric fever in Islington, also in the same year, by Dr. Ballard, now of the Local Government Board. Subsequent to that date numerous other outbreaks were reported, but perhaps the most notable amongst them was the outbreak of enteric fever in Marylebone, London, investigated by Mr. Power and the late Mr. Netten Radcliffe, in 1873, when it was proved beyond a doubt that the water used for dairy purposes on a particular farm, from which the milk was obtained, contained excremental matters from a patient suffering from enteric fever immediately before and at the time of the outbreak. (See Mr. Simon's *Reports*, New Series, No. II.)

In a paper read before the International Medical Congress in 1881, Mr. Ernest Hart gave a tabulated account of as many as 71 epidemics due to infected milk, 67 of which had been made the subject of detailed inquiry since the date of the Marylebone outbreak. Of these 50 were epidemics of enteric fever, 14 of scarlatina, and 7 of diphtheria; while the number of cases traceable to each of these diseases in the various outbreaks was estimated at 3500, 800, and 500 respectively. As regards enteric fever, the contamination of the milk was in 22 out of the 50 epidemics traced to the use of specifically polluted water for "washing the milk-cans," and no doubt in all of them water was the prime agent in producing the disease. In outbreaks of scarlatina, on the other hand, the milk absorbs the *contagium* given off by the skin

and lungs, and in the majority of recorded outbreaks it has been found that persons employed in the dairy were in attendance on patients suffering from the disease, or that the disease itself existed in the dairy. But with regard to diphtheria, the exact exciting cause has not been so easily traced. In a report presented to the Local Government Board, Mr. Power, in describing an outbreak of diphtheria which occurred in North London in 1878, was led to the conclusion that garget or inflammation of the udder of the cow may have induced the disease, but this conjecture has not been corroborated by other inquiries. Very probably in diphtheria, the milk becomes sometimes tainted through aerial agency, the breath being the contaminating agent; and as we know that diphtheria is frequently traced to polluted water, it may be reasonably supposed that milk tainted with such water would also produce the disease. Moreover, as has previously been pointed out, it is highly probable that the milk from cows, which calves suffering from throat affections are occasionally allowed to suckle, may induce diphtheritic symptoms in those using the milk. Recent outbreaks of diphtheria traced to milk-supplies have occurred in Plymouth, Hendon, and the north of London.

But in addition to diphtheria, certain obscure throat affections have been traced to a tainted milk-supply, and notably an outbreak which occurred in Aberdeen in 1881. In this outbreak the sufferers were attacked by severe rigors, followed by febrile symptoms and extreme prostration. The tonsils were slightly enlarged, but there was no false membrane, while a marked feature was the swelling of the glands of the neck, and those above the clavicle. Over 300 persons sickened within a short time, and 90 families were attacked out of a total of 110 supplied by the same dairy. So soon as the milk-supply was stopped, the farther spread of the disease was at once

arrested; indeed, its disappearance was as sudden as its onset. In this instance the water-supply was obtained from an uncovered cistern in the cow-shed, and on analysis it was found to be polluted; but though suspicion attached to the water, the abruptness of the outbreak points rather to some temporary tainting agency which was not discovered, although it was found to be connected with minute organisms in the milk. (*Sanitary Record*, 1881.)

Although other serious outbreaks might be quoted, these are sufficient to prove that milk is a far more frequent agent in the spread of disease than is generally suspected; and, for my own part, I am inclined to believe that many obscure cases of enteric fever, and much of the autumnal diarrhœa, which occur in rural districts, are due to polluted milk. Indeed, several scattered cases of enteric fever have come under my own notice, in which, although there was no evidence to show that the specific virus had been introduced, it was clear enough that the well was contaminated with sewage, and that the milk-cans had been washed with the polluted well-water, even if the milk itself had not been diluted with it.

So far the inspection of dairies and cow-sheds, under the Code of Regulations issued by the Privy Council in 1879, has been of very doubtful benefit, and indeed in most parts of the country the code has not been put into operation. The duties ought certainly to be transferred from the County Magistrates sitting in Quarter Sessions to the Sanitary Authorities. (See Appendix.)

CHAPTER III.

AIR: ITS IMPURITIES, AND THEIR EFFECTS ON PUBLIC HEALTH

SECTION I.—COMPOSITION.

PURE AIR, according to the analyses of the late Dr. Angus Smith, is composed of 20·99 per cent by volume of oxygen, ·033 per cent of carbonic acid, and the rest of nitrogen, watery vapour, and traces of ammonia. With the exception of carbonic acid and aqueous vapour, the relative proportions of the other constituents remain tolerably constant throughout the globe. In this country the amount of oxygen varies from 20·999 per cent in the sea air on the coast of Scotland, to 20·910 in Manchester during frost and fog, while the carbonic acid ranges from ·03 to ·05 per cent. The following averages of analyses, quoted from Dr. Smith's work on *Air and Rain,* represent the more important variations in the open-air percentages of carbonic acid:—

	Carbonic Acid in 100 parts Averages.
Different parts of Scotland, and at various altitudes .	·0336
Perth City and outskirts	·04136
Closer parts of Glasgow	·0539
Opener parts of Glasgow	·0461
Suburbs of Manchester	·0369
Streets of Manchester	·0403
Open places of London	·0301
Streets of London	·0341
Lake of Geneva (Saussure's analysis) . .	·0439

It also appears that the air of the highest mountains contains more carbonic acid, less oxygen, and less organic matter, than the air of plains, and that the quantity of oxygen is always sensibly diminished in the air of towns.

The amount of aqueous vapour fluctuates greatly, and is mainly influenced by temperature. At a given temperature air cannot contain more than a certain quantity of moisture in suspension, and when it has taken up this quantity it is said to be saturated. In general, the air contains from 50 to 75 per cent of the amount requisite for complete saturation, the average amount being about 1·46 in 100 parts. If the quantity be not within these limits, the air is either unpleasantly dry or moist.

The ammonia, which exists as carbonate, chloride, sulphate, or sulphide, is present only in very minute quantities, and does not exceed one part in a million parts of air.

In addition to these ingredients, ozone may perhaps be reckoned as a normal constituent, and spectroscopic analysis has shown that the salts of sodium are everywhere present in greater or less abundance.

Section II.—Impurities in Air, and their effects on Public Health.

Preliminary Remarks.—Impurities in air may be roughly divided into suspended and gaseous matters. While the presence of suspended matters is rendered familiar to every one in the shining particles which become visible in the direct rays of the sun, the well-known demonstrations by Professor Tyndall with the electric light have shown, perhaps more forcibly than heretofore, their almost universal diffusion. Particles of silica and silicates, of calcium carbonates and phosphates, of iron salts, and, in short, of every chemical constituent

of the soil, are lifted by the winds and carried hither and thither. In inhabited places, carbon particles, hairs, fibres of cotton, wool and other fabrics, starch-cells, etc., are found in great abundance. From the vegetable world are wafted seeds and the *débris* of vegetation, as well as spores, germs, pollen, and volatile substances. In like manner, the animal kingdom supplies germs of vibriones, bacteriæ, and monads, and particles of decayed or decaying tissues, such as epithelium and pus cells.

The numerous gaseous matters which pass into the atmosphere, and render it impure, will be more conveniently noticed in the subsequent remarks concerning overcrowding, and the injurious effects of different trades and manufactures.

But there are other organic vapours arising from the decomposition of vegetable and animal products which merit special attention, as, for example, those contained in the air of marshes and sewers. The exact chemical composition of these vapours still remains a mystery. Equally obscure too is the nature of those organic substances which constitute the specific poisons of contagious diseases. Whether they consist of inconceivably minute particles of decaying matter, or of living microscopic germs; whether, in some instances, they are conveyed by epithelium and pus cells from the diseased to the healthy, or are condensed with the watery vapour of the atmosphere, and thus disseminated;—all these are questions which have yet to be satisfactorily answered. Certain it is, that in a large proportion of cases the atmosphere is made the vehicle of the contagium or morbific agent, whatever its nature; and hence the paramount importance of adopting such measures as will prevent contamination of the air; or at all events aid in dissipating or destroying its more noxious impurities. It is true some of the operations of Nature are in themselves calculated to

accomplish this end. Injurious gases become diffused, diluted, or decomposed; animal emanations are absorbed in the processes of vegetation; suspended matters are washed down by the rains, or fall by their own weight; while many organic substances are oxidised, and thus rendered innocuous. Were it not for these purifying agencies, which are in constant activity, sanitary measures would prove futile; and, indeed, they are only successful in so far as they approximate to the preventive and remedial means which Nature employs.

1. *Air vitiated by Respiration.*—The effete matters thrown off in respiration are carbonic acid, watery vapour, and certain undefined organic substances.

According to Dr. Carpenter, who has summarised the results obtained by various physiologists, an adult man, under ordinary circumstances, gives off 160 grs. of carbon per hour. In both sexes the amount increases up to about the thirtieth year, but beyond the eighth year the exhalation is greater in males than in females. Dr. Parkes has given the average amount of carbonic acid exhaled by an adult in the twenty-four hours as 16 cubic feet, or a little over ·6 cubic feet per hour.

The quantity of watery vapour thrown off by the skin and lungs varies according to the hygrometric condition of the atmosphere. It has been estimated at from 25 to 40 oz. in the twenty-four hours, and requires, on the average, 210 cubic feet of air per hour to retain it in a state of vapour.

The organic matter given off has never been accurately determined. It has a very fœtid smell, and is but slowly oxidised. It is believed to be molecular, and may be said to hang about a room like clouds of tobacco-smoke, and, like tobacco-smoke, the odour is difficult to be got rid of, even after free ventilation has been resorted to. It darkens sulphuric acid, and decolourises solutions of potassium permanganate. When drawn through pure

water it renders it very offensive. It is certainly nitrogenous, and probably in combination with water, because hygroscopic substances absorb it most readily. According to Lemaire, Trautman, and others, it contains minute cellular bodies named "putrefaction-cells," which have been found to bear a close resemblance to the so-called bacteriform puncta which Dr. Macdonald of Netley has detected in foul water. In sick-rooms it is associated with pus-cells and other emanations of disease. As much as 46 per cent of organic matter has been found in plaster taken from the walls of a hospital ward in Paris.

As the ammonia, and more especially the albuminoid, may be taken as an index of the amount of organic impurities contained in air collected at various places, the following summary of analyses, by Dr. Angus Smith, is instructive :—

Air obtained from	No. of Experiments.	Free Ammonia. Grains per Million cubic feet.	Albuminoid Ammonia. Grains per Million cubic feet.	Total Ammonia. Grains per Million cubic feet.
Innellan (on the banks of the Clyde) . . .	1	22·845	60·228	83·073
London	18	26·780	65·947	92·727
Glasgow. . . .	4	34·169	133·264	167·433
A bed-room. . .	3	44·305	104·118	148·423
A midden . . .	3	146·911	181·524	328·435

According to a report on the air of Glasgow by Dr. Russell and Mr. Dunnachie, published in May 1879, nitrogen, as free and albuminoid ammonia, was found to be always in excess in the two centric stations of observation in the city, when compared with analyses made of the air collected at an eccentric station; but it was also found that the amount of potential or albuminoid ammonia became much lower in the month of July, clearly showing, especially when the amount of sulphur is taken

into account, that both forms of ammonia are "largely derivatives of the rapid combustion of fire applied to wood or coal." These experiments have been confirmed to a certain extent by those which have been carried on for some time back at the observatory of Mountsouris, in the neighbourhood of Paris, and serve to prove that the amount of ammonia cannot be relied on as an index of the insalubrity of air without taking into account the natural history of each sample.

Practically speaking, the amount of organic matter in air vitiated by respiration is found to increase as the carbonic acid increases. According to Dr. Parkes it becomes distinctly perceptible to the sense of smell when the carbonic acid in an inhabited room amounts to ·7 per 1000 cubic feet of air—a statement which has been frequently verified by other experimenters.

Briefly, then, the changes produced in an occupied air-space by respiration and transpiration are the following:—The amount of oxygen is greatly lessened, the carbonic acid and watery vapour are largely increased, ammonia and organic matter are evolved, and suspended matter in the shape of low forms of cell-life and epithelium scales is thrown off.

The effects of breathing considerable quantities of carbonic acid in air otherwise pure have not yet been determined with sufficient accuracy. Dr. Angus Smith has found that 30 volumes per 1000 cubic feet of air produced great feebleness of the circulation, slowness of the heart's action, and quickened respiration, but he experienced no discomfort in a soda-water manufactory, where the amount was 2 per 1000 volumes. On the other hand, Pettenkofer and Voit found that no discomfort was experienced from long exposure when as much as 10 per 1000 volumes was present. In respired air, however, headache and vertigo are undoubtedly produced

in many persons when the carbonic acid exceeds 1·5 per 1000 volumes; but probably this is as much due to the presence of organic effluvia, and the diminution in the quantity of oxygen, as to the increase in the amount of carbonic acid. Yet it must be borne in mind that even a small excess of carbonic acid interferes with healthy physiological action, inasmuch as it prevents the sufficient exhalation of the gas itself, and induces an undue accumulation of it in the blood. In like manner, the quantity of oxygen absorbed is lessened, and there is consequently a retardation of those oxidising processes which are requisite for the complete elimination of effete matters from the system. But while there is always an increase in the amount of carbonic acid, there is likewise, as already pointed out, a marked diminution in the quantity of oxygen in respired air. Thus Dr. Angus Smith found that the percentage of oxygen in the open air of a suburb of Manchester amounted to 20·96; in a sitting-room, to 20·89; in the pit of a theatre, to 20·74; in the Court of Queen's Bench, to 20·65; and in the sumpt of a mine, to 20·1400. It does not follow that, because pain or discomfort is not always experienced in a vitiated atmosphere, no harm has been done. The effects may be slowly and imperceptibly cumulative, but they are none the less injurious, and they are now recognised as being amongst the most potent and wide-spread of all the "predisposing causes" of disease.

Speedily fatal results, arising from overcrowding and the want of fresh air, are familiar to every student of medicine. Out of the 146 prisoners confined in the "Black-Hole of Calcutta," 123 died in one night; and it is significant that many of the survivors afterwards succumbed to "putrid fever." Nor have similar instances been wanting in this country. Of the 150 passengers that were shut up in the cabin of the Irish steamer *Lon-*

donderry, with hatches battened down during a stormy night in 1848, 70 died before morning. No doubt, in these two catastrophes, the direct cause of death was asphyxia; but the fact that "putrid fever" attacked many of those who were carried out alive from the Black-Hole of Calcutta showed that the fœtid exhalations to which they were exposed must have aided largely in destroying the lives of the immediate victims. Indeed, it is admitted by all physiologists that the re-breathing of fœtid matter thrown off by the skin and lungs produces a kind of putrescence in the blood, in proportion to the amount inhaled and to the period of exposure to its influences. Of this species of poisoning the history of the "Black Assizes," in the sixteenth, seventeenth, and eighteenth centuries, furnishes many terrible examples. Jail, or typhus, fever, according to Dr. Murchison, was frequently generated *de novo* solely in consequence of the disastrous effects of overcrowding and deficient ventilation, and the disease thus generated often spread from the court-house, where the prisoners were tried, to the surrounding population. "My reader," said John Howard, "will judge of the malignity of the air in jails, when I assure him that my clothes were, in my first journeys, so offensive, that in a post-chaise I could not bear the windows drawn up, and was therefore often obliged to travel on horseback. The leaves of my memorandum book were often so tainted that I could not use it until after spreading it an hour or two before the fire." Even so late as 1815, Harty showed that typhus was being constantly generated in the prisons of Dublin whenever they became overcrowded with convicts prior to the periodical transportation of the accumulated numbers to a penal settlement. Or, to come to more recent times, one finds Dr. Buchanan reporting to the medical officer of the Privy Council regarding an extensive epidemic in Merthyr Tydfil in the beginning of

1870, that it was true typhus fever, and that he referred it to overcrowding, and to want of ventilation in the houses of the poorer people.

Such are some of the more direct and palpable effects of overcrowding and deficient ventilation; but there are others, perhaps equally grave, though not so well pronounced, which cannot be overlooked. All the so-called zymotic diseases, for example, are more specially fatal, and spread with the greatest virulence, in densely populated and badly ventilated districts; and it is in these "fever-nests" that epidemic diseases, which prevail during certain septic conditions of the atmosphere, are attended with the highest mortality and the greatest sick-rate.

Of other diseases developed by respired air there can be no question that phthisis pulmonalis holds a prominent place on the list. A large mass of evidence has been collected from various sources bearing on this point, but the fact is now so fully recognised by the medical profession generally that a few instances will suffice. In the celebrated Report of the Army Sanitary Commission, published in 1858, it was proved beyond all doubt that the excessive mortality from consumption amongst soldiers, and in particular regiments, was due to overcrowding and insufficient ventilation. Previous to that inquiry the cubic space per soldier in the barracks of the Foot Guards only amounted to 331 cubic feet, and the phthisis mortality was as high as 13·8 per 1000. In the Horse Guards, on the other hand, with a space per man of 572 cubic feet, the mortality from phthisis did not exceed 7·3 per 1000. It was found that phthisis prevailed at all stations, and in the most varied and healthy climates, the vitiated air in the barracks being the only condition common to all of them. In consequence of this excessive mortality, the Commissioners recommended that the cubic space allowed per man in barracks should be increased,

and the ventilation improved, with the result that, from the time their recommendations were acted upon, the number of phthisical cases occurring at all these stations has materially diminished. Similar evidence is afforded by the statistics of the Royal Navy, and notably as regards the civil population, in the Report of the Health of Towns Commission, published in 1844. Indeed, it has been fully established that not only phthisis, but other lung affections, such as pneumonia and bronchitis, are generated to a large extent under like conditions, and the same may be said of such diseases as scrofula, and others of an adynamic type.

When air is vitiated by the exhalations of the sick, as in hospitals, there is a risk of gangrene and erysipelas spreading, especially in the surgical wards. The period of convalescence in many cases is retarded, and the mortality rate increased. Pus-cells and putrefying particles are thrown off from purulent discharges, and, finding a suitable nidus elsewhere, may communicate a special disease, and thus act as a true contagium. The prevalence of purulent ophthalmia, under certain conditions, and the spread of lung-disease in badly-ventilated ships, when the disease appeared to be propagated from person to person, can only be fully explained on some such theory as this.

2. *Air rendered impure by Sewage and Cesspool Effluvia.* —Amongst the gases generated by the decomposition of fæcal matter, whether occurring in sewers or cesspools, may be enumerated carbonic acid, nitrogen, sulphuretted hydrogen, light carburetted hydrogen, and ammonium sulphide. Dr. Letheby found that sewage-water, excluded from air, and containing 128 grs. of organic matter per gallon, yielded 1·2 cubic inches of gas per hour during a period of nine weeks. But the amount of gaseous products given off under ordinary circumstances must vary greatly, according to the dilution of the sewage, the

rapidity of flow, temperature, ventilation of the sewers, etc. In comparing the results of analyses made by various chemists, it would appear that the oxygen is diminished, and the carbonic acid greatly increased, but that sulphuretted hydrogen and ammonium sulphide, when present, exist only in very small quantities. The peculiarly fœtid smell of sewage gas is therefore owing to the presence of organic matter, whose exact chemical composition, however, has not been determined. Dr. Odling believes it to be carbo-ammoniacal. It is alkaline in reaction, and speedily decolourises solutions of potassium permanganate. According to Dr. Cunningham, it contains distinct bacteria, and other low forms of cell-life. Like other organic effluvia, it promotes the growth of fungi, infects milk, and taints meat.

It is doubtful whether the effects of sewer-air upon the health of men employed at work in sewers can be said to be very injurious. Indeed, the researches of Dr. Guy and Parent du Chatelet, at first sight, go to prove that this class of labourers enjoy a marked immunity from diseases which can be attributed to sewer-emanations; but, as has been shown by the late Dr. Murchison, there are several elements of error in their statistics which mar their conclusions. For example, Dr. Guy's researches were made before enteric and typhus fever were fully recognised as distinct diseases, and Parent du Chatelet's statistics were not only too scanty for a fair deduction, but the majority of the sewer-men whom he examined had been employed at that special work for only a short period. According to Dr. Murchison's experience, enteric fever is by no means uncommon among these men, and Dr. Peacock's inquiries led him to express a similar opinion. But whatever the issue of this question, it seems to be quite certain that constant exposure to sewer-gases diminishes the risk of being in-

jured by them. A remarkable instance of this apparent immunity enjoyed by workmen, and the disastrous effects upon those whose exposure to such gases was only casual, is afforded by an event that occurred at Clapham in the autumn of 1829:—20 out of 22 boys at the same school were seized with violent vomiting, purging, prostration, and fever, within three hours. One boy had been seized with similar symptoms two days before, and died; another also succumbed. So alarming was the outbreak that poisoning was suspected, but, after careful investigation, it was found that the sole cause of disease was to be attributed to the opening of a drain at the back of the house. This drain had been choked up for many years, and had been opened two days before the first illness occurred. The effluvia from the drain were most offensive, and the boys had watched the workmen cleaning it out; none of the workmen, however, were subsequently attacked with any of the symptoms which so seriously affected the boys.—(*Murchison.*)

While numerous other instances are recorded of the evil effects of the air of sewers, cesspits, drains, etc., in producing temporary ailments, such as nausea, vomiting, diarrhœa, and headache, the great interest which attaches to this important subject rests on the development and spread of enteric fever. Without entering at present into the discussion as to whether this fever is purely specific, or may be generated *de novo*, there can be no question that the polluted air from cesspits, drains, and sewers becomes the medium through which the disease is frequently propagated, if not engendered. The sewer-air, laden with *morbific ferments* or *contagia*, readily finds its way into houses, more especially in cold weather, on account of its greater tension, and in consequence of badly trapped or imperfectly ventilated drains. It may be inappreciable to the senses, but its baneful effects

make themselves felt none the less, and frequently exhibit themselves in houses which in other respects are replete with every comfort which wealth can command. Indeed, it would appear that persons of the upper and middle ranks in towns are more liable to be attacked by enteric fever than the poorer classes, and for this reason—the houses of the former are more generally connected with sewers, and, either from structure or situation, are of higher elevation, so that the light sewer gases, in obedience to natural laws, are more apt to accumulate in the drains of such houses, and, when the drains are not properly disconnected and efficiently trapped or ventilated, to effect an entrance into the houses themselves. Thus it happens that a system of sanitary engineering, which is intended to prevent, and does prevent, the development of disease, not unfrequently furnishes the readiest means for its propagation. For example, the outbreak of enteric fever in York which prevailed in the autumn of 1884, and was investigated by Dr. Airey of the Local Government Board, was attributed by him "to the exhalations from the ill-ventilated sewers, under the influence of a very dry and warm season." (*Special Report to the Local Permanent Board*, 1885.) All outbreaks of this description, however, could be frustrated if sewers and drains were kept properly flushed and ventilated.

Two other points connected with the propagation of enteric fever deserve notice: (1) it seems to be clearly established that the disease may be contracted by inhaling the effluvia from enteric stools previous to their being disposed of; and (2), that if these stools be thrown into a common privy, the disease is almost certain to be conveyed to others who frequent the privy; hence the necessity of disinfecting all discharges from the patient so soon as they are passed. (For further remarks on this subject, see Chap. XV.)

Amongst other serious consequences of fæcal emanations, the occasional spread of cholera and the occurrence of autumnal diarrhœa are specially to be noted. The outbreak of cholera in the City of London Workhouse, in July 1866, was shown by Mr. Radcliffe (*Ninth Report of Medical Officer of the Privy Council*) to have taken place, in all probability, in consequence of a sudden efflux of sewer-air from a drain containing choleraic evacuations. Autumnal diarrhœa, again, is found to prevail when the season is warm and dry, and more particularly in badly-sewered districts. In speaking of this subject, Dr. Murchison says that "circumscribed autumnal epidemics of enteric fever are often preceded by an increase of diarrhœa, and the diarrhœa reaches its acme long before the fever does." After heavy falls of rain the sewers become well flushed, and the diarrhœa subsides. In country districts isolated outbreaks of diphtheria, traceable to cesspool effluvia, are not at all uncommon. In these cases it is generally found that there is a water-closet in the house which itself is badly ventilated, that the soil-pipe is never ventilated, and that the closet drain discharges into a cesspool which is completely covered up, and only cleaned out at rare intervals. The consequence is that any gases generated in the cesspool have no outlet except through the water-closet and into the house, and hence result attacks of diphtheria, ulcerated sore throat, and other badly defined ailments.

According to the evidence of Sir Henry de la Beche and Sir Lyon Playfair, in the Second Report of the Health of Towns Commission, there are strong presumptive grounds for believing that emanations from streams polluted by fæcal matter may be injurious to the health of inhabitants living on their banks. It is stated that many of them were pale, and suffered from dyspepsia, and that cases of fever, when they occurred, were increased in severity.

In other instances, however, no such effects have been traced.

When sewage matter is thrown over the ground, the exhalations given off have likewise been proved to be sometimes productive of serious disease. Thus, Dr. Clouston has recorded an outbreak of dysentery among the patients in the Cumberland and Westmoreland Asylum, which he attributed to the emanations from sewage applied to the land about 300 yards from the asylum. After this outbreak the sewage was allowed to fall into a small stream, and for two years the asylum had been free from the disease. At the end of this period, however, the sewage was again applied to the farm, and again the dysentery appeared, although all proper precautions were taken in the way of disinfecting and in applying the sewage. It is to be noted that there was a stiff brick-clay subsoil, and doubtless this prevented the sufficient percolation of the sewage into the ground.

3. *Effluvia from decomposing Animal Matter.*—Under this heading may be included—the effluvia from decomposing carcases; the air of graveyards; and the effluvia from manure, tallow, and bone-burning manufactories.

On almost all these points the evidence is very conflicting. The preponderance of opinion, however, leaves no room for doubt that the effects of all such effluvia upon the health of the general population, when exposed to their influence, are more or less injurious; and in support of this view the following amongst many other confirmatory instances may be quoted:—

(1.) The effluvia arising from the putrid remains of horses killed on the field of battle have frequently given rise to outbreaks of diarrhœa and dysentery amongst the soldiers. In the French camp, before Sebastopol, when numbers of the bodies of horses lay putrefying and un-

buried, the effects were so serious that the spread of typhus was supposed to be due to this cause.—(*Parkes.*)

(2.) According to the evidence summed up in the Report on Extramural Sepulture in 1850, the vapours given off from thickly crowded graveyards, if not actually productive of disease, do certainly increase the sick and death rate of the immediate neighbourhood.

(3.) Although the health of workmen employed in manure and similar manufactories does not appear to be injured by their occupation, the occasionally disastrous effects upon others, of the effluvia given off, are well illustrated by the following case:—In 1847, many of the inmates of Christ Church Workhouse, Spitalfields, were seized with violent attacks of diarrhœa, of an enteric type. It was found that whenever the works were actively carried on, and particularly when the wind blew from that quarter, there ensued an outbreak of diarrhœa in the workhouse. In December of the following year, when cholera was spreading in the neighbourhood, sixty of the children were attacked one morning with violent diarrhœa. In consequence of this outbreak the owner of the manufactory was obliged to stop work, and the children rapidly recovered. Five months afterwards the works were resumed, and again there was a similar outbreak amongst the inmates occupying the part of the building opposite the manufactory. The works were once more discontinued, and the diarrhœa ceased.—(*Carpenter.*)

The effluvia produced in tallow-making and similar trades, though sometimes very offensive, and therefore an undoubted nuisance in inhabited districts, do not appear to have produced any serious effects which have been recorded. According to Dr. Ballard, however, they often induce headache, nausea, and sometimes diarrhœa. (*Report of Med. Officer, Local Government Board,* 1876.)

4. *Gases and Vapours given off by Alkali Works,*

Chemical Works, and Brickfields.—(1.) The principal gas evolved in alkali works is hydrochloric acid. Its effects on vegetation are very destructive, but with proper care in the condensation of the gas, there does not appear to be any evidence to show that works of this description are injurious to the health of those living in the neighbourhood.

(2.) From chemical works, and especially from those in which gas liquor is utilised for the production of salts of ammonia and other chemical compounds, the injurious gases evolved consist chiefly of sulphuretted hydrogen, ammonium sulphide, and traces of other ammonium compounds. The workmen employed at such works apparently enjoy good health, but when the noxious vapours are not properly consumed by being collected and passed through a furnace, there is no doubt that they do affect the health of the neighbouring inhabitants, though not to any serious extent.

(3.) The peculiarly pungent odour of brickfields can be felt at several hundred yards' distance; but though several cases are recorded in which the existence of a nuisance was fully established, none are quoted as having proved that the health of the neighbourhood was affected.

5. *The Air of Marshes.*—This generally contains an excess of carbonic acid, light carburetted hydrogen, watery vapour, sulphuretted hydrogen, and organic effluvia. It also abounds with the *débris* of vegetable matter, infusoriæ, and insects.

The more serious and characteristic effects of marsh miasmata are intermittent and remittent fevers. Ailments, however, of a less severe nature—such as diarrhœa, dysentery, and various other gastric derangements—have been attributed to their influence; and even when no marked signs of disease can be detected, the inhabitants of such districts often present an enfeebled and pallid

appearance. The submerging of meadows, draining of lakes, and digging of canals, have all of them been followed by the development of marsh-diseases, probably on account of the decomposition of vegetable matter which ensues. For the same reason, a long continuance of dry weather, followed by rains, favours the evolution of miasmata. Fortunately, in this country, marsh-diseases have become comparatively rare, though there is no doubt that in low-lying and badly-drained districts the excessive sick-rate which often prevails is in a great measure owing to atmospheric impurities of a marshy nature.

6. *Air-Impurities in certain Trades and Occupations.*—The deleterious impurities under this heading consist chiefly of mineral and organic substances, as, for example, the particles of coal-dust in the air of mines; particles of steel and grit given off in grinding; arsenical fumes, in copper-smelting; zinc fumes, in brassfounding; pearl-dust, in button-making; organic dust or fluff, in shoddy and flax mills, etc. But the whole of this part of the subject is so extensive that only a few instances of the increased sick-rate and mortality produced by these impurities can be given here.

The habitual inhalation of coal-dust contained in the air of coal-mines results in what is called the "black-lung;" the pneumonic cells becoming gradually blocked up, so that, after death, the lung presents a peculiarly melanotic appearance. Cases of emphysema and chronic bronchitis were at one time very common amongst colliers, and the aggregate amount of sickness experienced by this class of workmen between the ages of 20 and 60 amounted to 95 weeks, or 67 per cent more than the general average.—(*Wynter*). No doubt much of the disease with which miners are liable to be attacked is to be attributed to the baneful effects of inhaling the products of combustion given off by candles,

lamps, etc.; because, when mines are well ventilated, as in Durham and Northumberland, lung affections are much less frequent.

But of all unhealthy occupations that of steel-grinders is perhaps the most fatal. Steel-grinding is divided into dry, wet, and mixed; the injurious effects varying according to the amount of water used on the stone. Forks, needles, backs of scissors, etc., are all ground on the dry stone, and, accordingly, the men and boys employed at this kind of work suffer most. The late Dr. Hall of Sheffield collected a large amount of information bearing upon this subject, from which the following particulars relating to the average duration of life of artisans in steel have been summarised. Dry-grinders of forks, 29 years; razors, 31 years; scissors, 32 years; edge-tool and wool-shears, 32 years; spring-knives, 35 years; files, 35 years; saws, 38 years; sickles, 38 years. Fans, however, are now more commonly used than formerly, while wet-grinding is becoming more general, and as a result of these and other precautionary means the average longevity of Sheffield grinders is increasing.

In the pottery trade, the flat-pressers and scourers at one time suffered to such an extent from the effects of the fine dust inhaled, that, according to Dr. Greenhow, almost all of them became eventually asthmatical.

Pearl-button makers, and workers in flax or shoddy mills, are liable to be afflicted more or less with bronchial irritation, and many of them with decided lung-disease. Cotton-weavers also suffer very much from the fine dust given off by the "sizing;" and some time ago an inquiry was made by Dr. Buchanan at Todmorden, which revealed the great prevalency of lung-disease, dyspepsia, and permanent epistaxis, amongst this class of operatives.

Amongst wool-sorters the disease known as anthrax, or malignant pustule, has at times proved very fatal, the poison

being conveyed into the system generally by inhalation of the fine dust given off in cleaning the wool, though it also may be conveyed by local inoculation. Two outbreaks have recently been investigated—one by Dr. Russell, Medical Officer of Health for Glasgow; and the other, which occurred at Bradford, by Dr. Spear, Local Government Inspector. (See *Supplements to Local Government Reports* for 1878 and 1880.)

In addition to asthma and bronchitis, brassfounders are very liable to attacks of an affection called "brassfounders' ague," the characteristic symptoms of which present themselves in the following sequence:—shivering, nervous depression, marked febrile disturbance, and profuse sweating. Flour-millers, sweeps, and snuff-grinders, are all of them apt to suffer from various forms of asthma.

Workers in lead are apt to suffer from "drooping wrist" and lead colic; lucifer-match makers, from necrosis of the lower jaw, caused by phosphorus fumes; and workers in mercury, from mercurialism.

In all these industrial employments it thus appears that the sick-rate and death-rate could both be very materially lessened by promoting ventilation, and by introducing some suitable appliances calculated to protect the workmen from the inhalation of fine dust or noxious fumes. But it was found that the workmen themselves often objected to any innovation which appeared to them to interfere with their more immediate comfort; and not a few of them were under the impression that the introduction of any measures tending to prolong life would be followed by such an overstocking of the labour market that the difficulties of procuring a living would be greatly increased. That such short-sightedness will continue to exist amongst certain numbers of the artisan class is only what may be expected. Disease sets in so insidiously and progresses so slowly, the stock of health to start with

seems so ample, and the individual prospect of death so remote, that sanitary rights are neglected and the wrongs quietly endured. No doubt, these widespread evils have been greatly mitigated of late years under the provisions of the Factory and Workshops Acts, but complaints are still made by inspectors that the workmen continue to be very careless about ventilation, and that they have a great aversion to using respirators, even when they know that their use is a safeguard against disease.

In Germany the whole of this subject has been very carefully studied by Dr Hirt, to whose elaborate work, *Die Krankheiten der Arbeiter*, I would refer all who are desirous of making themselves fully acquainted with injurious trades and the diseases which they severally induce, or are liable to induce, in those employed at them.

With respect to the effects of trade-nuisances on the general health of the community, a very important inquiry was conducted some few years ago by Dr. Ballard in behalf of the Local Government Board, which is of special interest to sanitary authorities and their officers throughout the country. Dr. Ballard's reports were published in the Supplements to the Local Government Board Reports for 1876, 1877, and 1878, and certainly rank as the most valuable and exhaustive contributions which have hitherto appeared on the subject. The trades embraced in the inquiry included—(1), the keeping of animals; (2), the slaughtering of animals; (3), branches of industry in which animal substances are principally dealt with; (4), trades in which vegetable matters are principally dealt with; (5), trades in which mineral substances are principally dealt with; and (6), trades in which matters of mixed origin are dealt with. According to Dr. Ballard, the most offensive effluvia are those given off from trade processes, in which the materials used consist of animal substances—such as gut scraping, manure manufacturing, and the melting of some

kinds of fat. The industries which deal with vegetable substances, though often very offensive, do not appear to give rise to effluvia which may be designated disgusting, and are therefore not so liable to be injurious; while those which treat mineral substances are chiefly offensive owing to the irritant gases and other effluvia which are given off. As might be expected, great difficulty was experienced in ascertaining, with any approach to precision, in what respect, and to what extent, these effluvia are injurious to health; but as regards all of them, it has to be noted that in records of proceedings of courts of law, and as the result of Dr. Ballard's inquiries, the particular group of symptoms generally complained of consisted of "loss of appetite, nausea, sometimes actual vomiting, sometimes diarrhœa, headache, giddiness, faintness, and a general sense of depression and *malaise*." Concerning effects of a more definite nature, Dr. Ballard points out that while trade effluvia generally contribute their quota of conditions which render the air of manufacturing towns comparatively insalubrious, there are certain effluvia of septic origin connected with businesses of a specially filthy nature, which are undoubtedly unwholesome, and give rise to filth diseases of various kinds. Other trades, again, in which matters are dealt with which are liable to be infected with specific contagia, cannot fail to be dangerous to persons exposed to such influence; while, as regards trades which give off effluvia consisting of definite chemical compounds, they are, as a rule, only irritating or injurious in proportion to their degree of concentration. It is often suggested by manufacturers, that because certain effluvia given off by chemical works are in common use as disinfecting agents, they must actually be beneficial to public health; but, as Dr. Ballard points out, this argument is altogether fallacious, inasmuch as such agents are virtually inoperative, unless applied in a degree of con-

centration far greater than the diluted effluvia often complained of outside the works.

In other respects, Dr. Ballard's reports are especially valuable, because they point out in detail not only the trades or trade processes which are most complained of as offensive, but they explain the methods in use, or which may be devised, for preventing or minimising the nuisances arising from them. This part of the subject, however, will be more fully treated in Chap. XVII.

CHAPTER IV.

VENTILATION AND WARMING

THESE two subjects may be conveniently treated under the following sections :—

I. The Amount of Fresh Air required.
II. The Necessary Amount of Cubic Space.
III. Natural Ventilation.
IV. Artificial Ventilation and Warming.

SECTION I.—THE AMOUNT OF FRESH AIR REQUIRED.

As the air contained in an inhabited room cannot, under the most favourable circumstances, be maintained in as pure a condition as the external air, the object of ventilation is to reduce the impurities of respiration to such an extent that continued inhalation of them will not be detrimental to health. While this can only be effected by a constant supply of fresh air, it is evident that the quantity required will very much depend on the amount of impurities which may be allowed to accumulate in respired air without proving injurious. The first point, therefore, which has to be determined is the limit of maximum impurity consistent with the maintenance of perfect health. It has already been shown that the amount of carbonic acid in air vitiated by respiration is a tolerably reliable index to the other impurities; and hence the question resolves itself into this,—What amount

of carbonic acid shall be accepted as the standard of permissible maximum impurity? After numerous experiments, and a most extended inquiry, Dr. Parkes has given it as his opinion that, allowing ·4 volume as the average amount of carbonic acid in 1000 volumes of air, this standard ought not to exceed ·6 per 1000 volumes; because, when this ratio is exceeded, the organic impurities, as a rule, become perceptible to the senses. With a ratio of ·8, ·9, or 1 per 1000 volumes, the air smells stuffy and close, and beyond this it becomes foul and offensive.

Perhaps there is no class of buildings which present better opportunities for arriving at an approximate and practical solution of this problem than prisons; and it may prove of some service if I record briefly the results of some experiments which some few years ago I had a share in conducting, and which are strongly corroborative of Dr. Parkes' views. In one of the English convict prisons one-half the prisoners are kept in separate confinement, except when at exercise; the other half are confined in their cells only during the night and when at meals. The cubic space and ventilating arrangements in the part of the prison occupied by the former were such that the average ratio of carbonic acid, after a series of observations made at different hours of the night, was found to be ·720 per 1000 volumes; while in the part of the prison occupied by the latter the cubic space was much smaller, and the average amount of carbonic acid was as high as 1·044 per 1000 volumes. The same number of observations were made in both parts of the prison at the same hours during the night-time, so that a strictly fair comparison could be drawn. Now, a careful inspection of the two classes of prisoners resulted in showing that whereas the former were well nourished and healthy-looking, the latter presented a somewhat less robust and more pallid appearance; and after eliminating

every source of error, this difference in appearance could only be accounted for by the difference in the amount of impurities contained in the respired air of both parts of the prison.

I have had many other opportunities of examining into this point, and would say, in general, that when the carbonic acid does not exceed ·8 per 1000 volumes, no *tangible* injurious effects upon the health can be detected; but when it reaches 1 per 1000 volumes, the cumulative effects manifest themselves in producing a pallid dyspeptic appearance, and make themselves felt, in numerous instances, in general *malaise* of a morning, slightly coated tongue, nasty taste in the mouth, and headache.

The desirability of adopting Dr. Parkes' estimate as the standard of maximum impurity is also borne out by the observations and experiments of such eminent authorities as Professor Pettenkofer of Munich, Dr. Angus Smith, and Dr. de Chaumont. "We all avoid," wrote Dr. Smith, "an atmosphere containing ·1 per cent of carbonic acid in crowded rooms; and the experience of civilised men is, that it is not only odious but unwholesome. When people speak of good ventilation, they mean, without knowing it, air with less than ·07 per cent of carbonic acid. We must not conclude that because the quantity of carbonic acid is small, the effect is small; the conclusion is rather that minute changes in the amount of this gas are indications of occurrences of the highest importance."—(*Air and Rain.*)

Assuming, then, that ·6 carbonic acid per 1000 volumes is accepted as the standard of maximum impurity, the next question comes to be—How much fresh air must be supplied per head per hour, in order that the respired air should not contain impurities in excess of this standard? It has already been stated, in the previous chapter, that an adult man exhales on the average ·6 cubic

foot of carbonic acid per hour, and taking the initial carbonic acid contained in the atmosphere at the normal ratio of ·4 per 1000 volumes, the quantity of fresh air which should be supplied is found by calculation to amount to 3000 cubic feet per head per hour, in all cases in which the diffusion of the contained air is uniform. Of course, if a standard not so pure is fixed upon, the amount of fresh air required would be proportionately less. Thus, supposing the limit of maximum impurity to be ·7 carbonic acid per 1000 volumes, the amount required would be 2000 cubic feet; if ·8, 1500 cubic feet; and ·9, it would be 1200 cubic feet per head per hour. It is evident also that women and children would require a smaller supply than men, because they do not vitiate the air so rapidly.

The results obtained by actual experiment accord so closely with those which have been deduced from mathematical caluclation that some of them may be fitly quoted here. The following are given by Dr. de Chaumont (*Edin. Med. Journal*, 1867) as selections from a series of observations made at Aldershot camp:—In a room containing 18 men, with a supply of 1200 cubic feet of fresh air per head per hour, the carbonic acid was found to be ·855 per 1000 volumes; in another containing 13 men, with a supply of about 1700 cubic feet, it was ·759 per 1000 volumes; and in a third, containing 22 men, and with a supply of about 765 cubic feet per head per hour, it amounted to 1·2 per 1000 volumes. All these observations were made at the same hour (5 A.M.), and in barrack-rooms ventilated on the plan proposed by the Barrack Commissioners in 1861, which provided that at least 1200 cubic feet of fresh air should be delivered per head per hour.

But there are other circumstances in which it is necessary to augment the delivery of fresh air in order to

maintain the standard of purity. When lights are used, for example, and the products of combustion are allowed to pass into a room, a large supply is required to keep the contained air sufficiently diluted. Thus it is found that 1 cubic foot of coal gas destroys the oxygen of 8 cubic feet of air in combustion, and produces about 2 cubic feet of carbonic acid, besides other impurities. As a common gas-burner burns about 3 cubic feet of gas per hour, the importance of having these deleterious products of combustion carried off by special channels will be readily admitted.

It is evident also that the sick require a larger supply of fresh air than the healthy, for it has been found that when as much as 3500 to 3700 cubic feet have been delivered per patient per hour, hospital wards have not been free from offensive smell. Indeed, no greater proof can be afforded of the value of pure air than the excellent results obtained in surgical cases in times of war, and in medical cases when epidemics are raging, by exposing patients as much as possible to the external air.

Section II.—Cubic Space.

This should be large enough to permit the passage of 3000 cubic feet of air per head per hour, without producing perceptible draughts. If the cubic space per head is small, the renewal of air will necessarily be much more frequent than when it is large. Thus, with a space of 100 cubic feet, the contained air must be renewed thirty times per hour, in order that the standard amount be supplied; whereas, with one of 1000 cubic feet, only three renewals of air would be required. What, then, is the minimum amount of cubic space through which the standard amount of fresh air can be passed without perceptible movement? Professor Pettenkofer has answered this

question experimentally, and has found that by means of artificial ventilation, and with the aid of the best mechanical contrivances, the air in a chamber of 424 cubic feet can be renewed six times per hour without creating any appreciable air-currents. No doubt, therefore, such a space as this, or one somewhat smaller, can be efficiently ventilated, provided that perfect artificial means be employed, and the air warmed, but with natural ventilation this becomes impossible. Indeed, a change of air three or four times per hour is all that can be borne in this country without discomfort, and this would require an initial air-space of 750 to 1000 cubic feet. Practically speaking, the difficulties of ventilating small spaces efficiently are due not so much to the movement of the contained air as to the relative position of the inlets, these being of necessity so near the person that the draughts which are produced become disagreeable or injurious. This is well exemplified in the case of prisons. In hard-labour prisons, where convicts are confined in their cells only during the hours of rest, the cell-space seldom exceeds 200 cubic feet. The consequence is that in cold or inclement weather these draughts become so unpleasant that many of the prisoners block up the inlets as effectually as they can, and of course obstruct the ventilation to a serious extent. So far as my experience goes, it is difficult, even with the aid of a well-devised plan of ventilation, to supply the necessary amount of fresh air per head per hour without creating perceptible draughts occasionally, if the space be less than 600 cubic feet. I have further satisfied myself that with the same artificial appliances and arrangements, the air contained in small occupied spaces becomes much more impure than in large spaces. For example, in the experiments already alluded to in the last chapter, the cell-space in one-half the prison was 210 cubic feet, in the other half it was 614. The same means

for extracting the foul air through flues leading from every cell to a foul-air extraction shaft, in which a furnace was kept burning to produce a constant draught, were common to both parts of the building. Moreover, the fresh-air inlets were more amply provided for in the small than in the large cells, and yet the average amount of carbonic acid, after a series of observations, was found to be 1·044 per 1000 volumes in the former, and only ·720 in the latter.

With a small cubic space it is impossible to obtain uniform diffusion of the contained air, if a large amount of fresh air is supplied, because between inlet and outlet a direct current is established, and a considerable quantity of air passes right through without being utilised. Again, it is evident that if the ventilation is impeded or becomes arrested, impurities will collect with far greater rapidity in a small than in a large space, and this of itself is a great argument in favour of the adoption of an ample cubic space as a basis. Dr. de Chaumont, in his remarks on this point, writes:—"Let us suppose two occupied spaces, one of 500 and the other 1000 feet, ventilated so that the ratio of carbonic acid is ·06 per cent, and that from some cause or other the ventilation is arrested in both, the condition will then be as follows:—

"1000 feet		"500 feet	
"Ratio of impurity.		"Ratio of impurity.	
"After one hour .	·12 per cent.	"After one hour .	·18 per cent.
,, two hours .	·18 ,,	,, two hours .	·30 ,,
,, three ,, .	·24 ,,	,, three ,, .	·42 ,,
,, four ,, .	·30 ,,	,, four ,, .	·54 ,,
,, six ,, .	·42 ,,	,, six ,, .	·78 ,,
,, seven ,, .	·48 ,,	,, seven ,, .	·90 ,,

With ordinary means of ventilation (artificial excluded) both Dr. Parkes and Dr. de Chaumont have contended that the cubic space for a healthy adult ought at least to

be 1000 feet. It is true this is very much in excess of what is generally obtained. In the crowded dwellings of the poorer classes it seldom reaches 200 to 250 cubic feet; but then the disastrous effects declare themselves but too clearly in the increased rate of mortality. In metropolitan lodging-houses the allowance per head is as low as 240 cubic feet; and in the Dublin registered lodging-houses it is 300. The Barrack Commissioners, on the other hand, recommended a minimum space of 600 cubic feet for soldiers, insisting at the same time that the air should be renewed at least twice every hour. "The only safe principle," they said, "in dealing with the subject is to have a large margin for contingencies; and the question really is, not whether 600 cubic feet per man be too much, but whether 600 cubic feet per man be enough for all the purposes of warming, ventilation, and comfort." Experiments that have since been made, and particularly those conducted by Dr. de Chaumont, prove most incontestibly that even this comparatively large allowance is inadequate for these purposes; but it was as much as could be obtained at the time, without putting the country to enormous expense. The Commissioners themselves observe:—"It has been said that the question of cubic space is simply a question of ventilation, but it is rather a question as to the possibility of ventilation. The more beds or encumbrances you have in a room, with a limited cubic space, the more obstruction you have to ventilation; the fewer the beds, the more easy is it to ventilate the rooms. There are fewer nooks and corners, fewer surfaces opposed to the movement of the air, and less stagnation. We have been in rooms, both in barracks and hospitals, in which the atmosphere was positively offensive with the doors and windows open."

For further remarks on cubic space in hospitals, see Chapter on Hospitals.

In summing up this part of the subject, the following may be accepted as the standard conditions necessary for the requirements of *perfect* health :—

1. That the limit of maximum impurity of air vitiated by respiration ought not to exceed ·6 carbonic acid per 1000 volumes.

2. That to ensure the maintenance of this standard under ordinary circumstances, 3000 cubic feet of pure air must be supplied per head per hour.

3. That for this purpose, and with ordinary means of ventilation, a space of at least 1000 cubic feet should be allowed per head in buildings permanently occupied.

It may be objected that these conditions aim at too high a standard, and that in general they are seldom met with ; but it must be remembered that they are based on a firm foundation of facts, and that, though it may not be possible to prove in all cases that bad effects result from a neglect of them, it does not follow that such bad effects may not have been produced. In a country like this, with a climate so variable, the cubic space allowance is a most important element in any scheme of ventilation. It should be ample enough to permit of a sufficient supply of fresh air without creating injurious draughts, and yet not too large to interfere with the maintenance of a sufficient and equable temperature during cold weather. Where artificial ventilation is provided, and when the fresh air can be heated before entering, it may be as low as 400 cubic feet, but even then the ventilating arrangements must be much more perfect than they usually are. In the case of healthy adults, such as soldiers and prisoners, the standard allowance may also be considerably lessened, if care be taken that the free entrance of fresh air at all hours and in sufficient quantity shall not be interfered with. Unfortunately the question of cubic space is a question of large outlay, and hence

the desire to economise tends to curtail the minimum not within safe limits, but within limits that will not be attended with glaring injurious effects.

In advocating these conditions, however, it is but right to state that the numerous experiments and weighty opinions of the late Dr. Angus Smith are somewhat at variance with them. In the first place, Dr. Smith's experiments only give ·4 cubic feet of carbonic acid per hour, which would reduce the requisite amount of fresh air supply per hour to 2000 cubic feet; and, in the second place, Dr. Smith maintains that uniform diffusion of the contained air is the exception and not the rule, and in fact that it does not occur at all. With regard to the first of these points, the discrepancy between Dr. Smith's results and those of other physiologists may be reconciled on the ground that his trials were admittedly not made on large men; but with regard to the second, there still exists considerable divergence of opinion. If by uniform diffusion throughout an occupied space is meant the *exact* uniformity of the chemical composition of the air in every part, then it must be conceded that Dr. Smith is strictly correct; for so long as fresh air is entering and foul air issuing from a room, there will not only be a difference between the composition of the air in the immediate proximity of the inlets and outlets, but there will also be a difference in various parts caused by the currents, however imperceptible these may be. In small occupied spaces, such as prison cells, provided with adequate means for artificial ventilation, the amount of fresh air required to keep the carbonic acid from exceeding ·6 per 1000 volumes must obviously be much less than the amount required per head in a large room, because uniform diffusion is impossible, there being a constant movement of the air from inlet towards outlet. But in a large space the case is different, even though the cubic space per head

be not greater than that of the prison cell. The entering currents and the currents produced by inequalities of temperature are, in this instance, much more numerous, and produce a much greater mixing of the air, while the impurities given off by respiration have greater scope to be affected by the laws of gaseous diffusion. For all practical purposes, therefore, the condition of uniform diffusion, as applying to a room occupied by several persons, may be accepted as sufficiently accurate; and this being so, the standard amount of fresh air to be delivered per head per hour should, as already stated, be 3000 cubic feet. Indeed, the whole of the controversy between Dr. Angus Smith, on the one hand, and Drs. Parkes and de Chaumont on the other, regarding this point, seems to be based on a misunderstanding; each party estimated the requirements of ventilation for a single individual, but under different conditions—the former taking it for granted that the space is occupied by one, the latter that it is occupied by several.

Section III.—Natural Ventilation.

Natural ventilation is carried on by the agency of natural forces, such as gaseous diffusion and movements of air produced by inequalities of temperature.

1. *Diffusion.*—The force of gaseous diffusion, upon which the uniform constitution of the atmosphere itself depends, is manifestly inadequate as a ventilating power. It operates chiefly in producing, as has been already stated, a tolerably equal distribution of the gaseous products of respiration and combustion throughout the air contained in a room, but aids only to a very slight extent the removal of these impurities from the room, while it is altogether inoperative as regards the removal of organic impurities.

2. *Movements of Air produced by Inequalities of*

Temperature.—As common air is subject, like other gases, to the laws of gaseous expansion, it undergoes a certain increase or diminution in bulk, according as it is heated or cooled. Warm air is, therefore, lighter than cold air, and hence a constant interchange goes on through every available opening, whenever there is any difference between the outside and inside temperature. The contained air on being heated expands, a portion of it escapes, and the colder outside air rushes in to establish the equilibrium. In this way a constant stream of fresh air may be made to enter a room by simply keeping the inside temperature higher than the outside. But in addition to the slighter currents, the movements of the external air, or winds, greatly assist ventilation by their perflating or aspirating action. Perflation is best exemplified in the cross-ventilation which takes place through opposite windows when opened. This is by far the readiest means which can be adopted for removing speedily and effectually aerial impurities from a room, but it cannot always be depended on, on account of the uncertainty of the rate of movement; for if the air be stagnant, there can be little or no perflation, while, on the other hand, if the rapidity of movement is great, perflation becomes insupportable in consequence of the draughts produced. A current of cold air moving at the rate of five or six feet per second becomes unbearable. In spite of this objection, however, cross-ventilation should always be provided for whenever it is practicable, and especially in large rooms, such as hospital wards.

The aspirating action of the wind produces up-currents through chimneys and air-shafts, by creating a partial vacuum in them, which is constantly being filled by the column of air from beneath. The mechanical arrangements which have been proposed or adopted to facilitate the action of these natural ventilating powers are so numerous and varied, that only a brief mention of the

more important of them can be given. To utilise the perflating force of the wind, opposite windows should be made to open from the top and bottom, and to obviate the unpleasantness arising from draughts, some such arrangements as the following have been recommended :—

(1.) By having the window so constructed that the top slopes inward when it is opened, so that the entering current of air impinges against the ceiling. If the window is large, as in churches or schools, only a section of the upper part may be made to open in this way.

(2.) By substituting a glass louvre for the top centre pane.

(3.) By having some of the panes doubled ; the outer with an open space at the lower edges ; the inner with an open space of the same size at their upper edges. The air on entering is thus made to pass upwards between the panes.

(4.) By having some of the panes made of perforated glass, as in Pott's plan.

(5.) By raising the lower sash of the window two or three inches and filling in the opening under the bottom rail with a piece of wood as proposed by Mr. P. H. Bird. This leaves a corresponding space between the meeting rails in the middle of the window through which the entering current of fresh air is directed towards the ceiling.

(6.) By having a part of a pane to open or shut at will by a spring arrangement, as in Boyle's ventilator.

(7.) By fixing a fine wire screen to the top of the window, which unfolds when the window is pulled down, and folds up when the window is shut. As the fine meshes of the screen are apt to become clogged up with dust, this plan is objectionable, except when the windows are of low elevation as in attic rooms.

Other outlets and inlets may be provided by inserting perforated bricks in the walls near the ceiling. One of

the best inlets is the Sheringham valve, which closes at will by a balanced weight. It slopes inwards and upwards when open, so that the entering current of air, which first passes through a perforated brick or grating, is directed towards the ceiling.

Currall's patent ventilators, supplied by Tonks and Sons, Birmingham, are easily applied, and appear to work very well. The inlet is made suitable for doors, windows, and walls, and is so arranged as to obviate disagreeable draughts, while the outlet may be inserted in the chimney-breast or an outer wall. Ellison's conical bricks, which are pierced with conical holes, are so constructed as to admit outer air without creating perceptible draught.

In some cases cross-ventilation can be tolerably well maintained, independently of opposite windows, by means of transverse ventilating boxes or tubes, situated at regular distances, and in close proximity to the ceiling. These boxes or tubes extend from wall to wall, and communicate with the external air at either end by air-bricks. The sides are made of perforated zinc, and there is a diaphragm in the centre of each, to prevent the wind from blowing right through. According to the direction of the wind, one-half the tube becomes an inlet for fresh air, which falls gently into the room through the perforated zinc, while the other half becomes an outlet for the vitiated air.

This plan does very well for large hospital wards having an internal corridor running along one side. Inner rooms can also be supplied with a certain amount of cross-ventilation in the same way.

Another plan which has been very much lauded within the past few years is that which is associated with the name of Mr. Tobin of Leeds. It consists in introducing fresh air by means of vertical tubes carried for a certain distance up the walls of the room, so as to obviate

any discomfort arising from down-draught. In rooms or class-rooms with windows only on one side, this is a very convenient method of improving the ventilation. A similar method of ventilating by pipes, introduced by Messrs. Shillito and Shorland of Manchester, has also been found to work very well.

The aspirating power of the wind is frequently utilised by placing cowls on the tops of air-flues or chimneys. If not made to rotate according to the direction of the wind by means of vanes, they should be so constructed as to prevent the entrance of rain. Among cowls which have received favourable notice may be mentioned the various cowls patented by Kite and Co., Banner, Boyle, Buchan and Ellison.

According to experiments conducted some time ago by a Committee of the Sanitary Institute at Kew Gardens, the great majority of cowls tested showed no superiority in aspirating power over the simple open tube.

Louvres are sometimes used instead of cowls, but, unless specially constructed, they are apt to let in the rain and permit down-draughts.

In several plans of natural ventilation the perflating and aspirating powers of the wind are both taken advantage of. Thus, in Mr. Sylvester's plan, which was in use fifty years ago, a large cowl surmounted the fresh air entrance shaft, and by means of a vane was always made to face the wind. The shaft itself was erected at a convenient distance from the building to be ventilated, and of a height varying according to circumstances. In this way the air, so to speak, was blown into the cowl and down the entrance-shaft into a chamber beneath the basement floor, where it could be heated if necessary. It then ascended by tubes leading to the different parts of the building, and finally passed out through a shaft or shafts projecting above the roof, and also

fitted with cowls turning away from the wind, so as to act as aspirators.

By a suitable arrangement of shafts and cowls, this mode of natural ventilation can be made to do excellent service in ships, and in buildings so constructed or situated that other ventilating means will not suffice. It was on this principle that Dr. Arnott ventilated the Field Lane Ragged School so successfully. The entrance and exit tubes were both fitted with cowls, the one set turning away from the wind, the other facing the wind. The latter also were of a higher elevation than the former, in order to increase their extractive power.

A system of natural ventilation, well suited for large rooms, and which has been highly spoken of by Mr. Robson, architect to the London School Board, is that devised by Mr. Potts. It consists of a hollow metal cornice running continuously round the room, and divided longitudinally throughout its whole length into two separate channels, by a plate attached to the lower one. The fresh air is admitted through openings in the wall into the lower channel, and falls imperceptibly into the room through numerous perforations. The upper channel communicates either with the smoke-flue or other air-shaft, and receives the vitiated air through a series of small openings similar to those of the lower channel. As the fresh air, being colder, descends by its own gravity, and the vitiated air, being warmer, rises to the highest point, there is no doubt that the principles of the system are correct. Mr. Robson strongly recommends it for facility of application to buildings originally erected without proper provision for ventilation, for sightliness, economy of first cost, and self-acting properties.

Another plan, which has been found to work well in schools, has been proposed by Mr. H. Varley. A perforated zinc tube, communicating with the external air,

passes along the cornice of three sides of the room, while on the fourth side another perforated tube is connected with the chimney, which acts as the extraction-shaft.

The plan proposed by Mr. M'Kinnell, though it belongs to the same category, is less widely applicable than either of these two, because it is only suited for one-storied buildings or upper rooms. It consists of two hollow cylinders, one within the other, and of such relative calibre that the transverse area between the tubes is equal to the sectional area of the inner tube. The inner tube is of slightly higher elevation than the outer, and acts as the outlet. The fresh air enters between the tubes, and is thrown up towards the ceiling by means of a horizontal flange surrounding the lower margin of the inner tube. Both tubes should be situated in the centre of the ceiling or roof.

For ventilating workshops or factories, another plan has been advocated, which appears to possess some special merits beyond those of mere novelty. It proposes that the ceiling of every workshop should be formed of zinc or oiled paper pierced by numerous small holes. Above this perforated ceiling, and between it and the roof, or between it and the next floor above, there should be a free space or air-chamber open to the atmosphere on all sides. This plan, while it would not interfere with ventilation by open windows nor with ordinary methods of warming, would give free play to the different modes of natural ventilation, and is intended to supply, as nearly as possible, the conditions of living in the open air, summer and winter, without exposure to extremes of weather.

Section IV.

Artificial Ventilation and Warming.

It will be convenient to consider these two subjects conjointly.

Artificial ventilation is carried on either by forcing the air into and through a room (propulsion), or by drawing the air out of a room (extraction). These two methods are also spoken of as the *plenum* and *vacuum* systems of ventilation.

Although it may appear to be an easy matter to ventilate a room without any regard to temperature, or to warm it without providing for a due supply of fresh air, it becomes a problem of very considerable difficulty to ensure, in all cases, that both the ventilation and warming shall be efficient and satisfactory. This difficulty depends in a great measure on the fact that the means employed in ventilating necessarily dissipate and carry off a certain quantity of the heat which should be utilised for warming purposes.

In this country artificial ventilation and warming are usually provided for by open fire-places. The heat is obtained by radiation from the incandescent fire, and by radiation and reflection from the different parts of the grate, while ventilation is carried on by the constant current of heated air rushing up the chimney. Even when there is no fire, the chimney acts as a very efficient ventilating shaft.

When doors and windows are closed and a fire kept burning, the fresh air enters the room through every chink and opening, provided there are no special inlets. Hence it follows that the more closely doors and windows are made to fit, so much greater are the obstacles to the entrance of fresh air. When this is the case, the

fire feeds itself by establishing a double current in the chimney, the downward current entering the room in puffs, and carrying with it clouds of smoke. Generally, however, doors and windows are not made to fit so closely that a sufficient amount of air for feeding the fire cannot enter, and under ordinary circumstances the supply and circulation are somewhat as follows :—The greater portion of the fresh air enters beneath the door, and is drawn along the floor towards the fire-place. It is warmed to a certain extent during its course by the radiating heat of the fire, and when it approaches the fire-place part of it rushes up the chimney along with the smoke, while the other part ascends towards the ceiling, and after ascending passes along the ceiling towards the opposite end of the room. During its progress it becomes cooled, and therefore descends to be again drawn towards the fire-place with a fresh supply from beneath the door and through the chinks of the window-frames, if they are not air-tight. As the air which thus enters is usually cold air, it is evident that the room is insufficiently or unequally warmed and badly ventilated. At the end of the room opposite the fire-place the temperature is below the average, and the cold current near the floor chills the feet. Moreover, the air is not properly diffused, so that although a sufficient supply may actually be entering, impurities are apt to accumulate in the centre and upper parts of the room.

The position of the fire-place is likewise a matter of considerable importance. The practice followed by most builders is to place fire-places in external walls, by which means a large amount of heat is wasted. If, on the other hand, they are grouped in the centre of the house, more heat is utilised, and greater equability of the inside temperature is maintained.

With ordinary fire-places it is found that nearly

seven-eighths of the heat generated passes up the chimney, along with a quantity of air varying from 6000 to 20,000 cubit feet per hour. While, therefore, a single chimney will on the average act as an efficient ventilating shaft for a room containing from three to six or more persons, it is quite clear that by far the greatest portion of the fuel is wasted as a warming agent. The structure of the fire-place thus becomes a matter of special importance, because not only may the fuel be economised to a considerable extent, but by certain mechanical arrange-

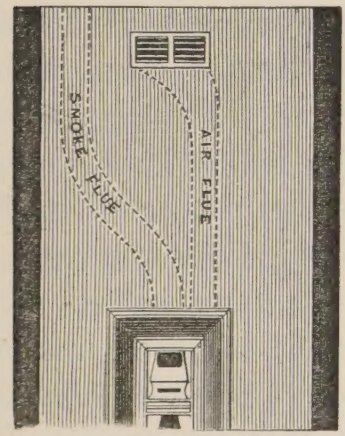

Fig. 1.—Elevation, showing air and smoke flues.

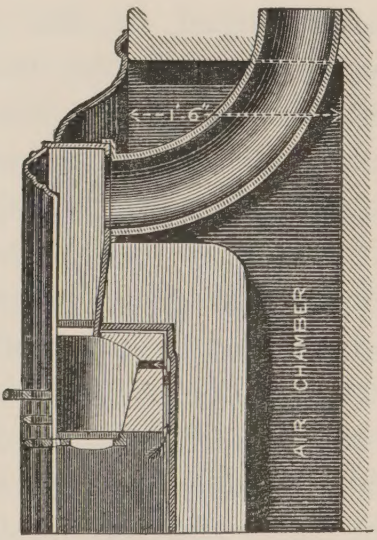

Fig. 2.—Section of grate.

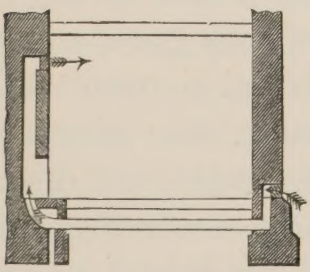

Fig. 3.—Section of a room showing air-duct and flues.

Fig. 4.—Plan of grate and air-chamber.

(After Galton.)

ments an equable temperature may be maintained and the air warmed before it enters the room.

Of the fire-places adapted to meet these requirements, one of the best and first devised, although it has now

many rivals, is the stove designed by Captain Douglas Galton (see Figs. 1, 2, 3, and 4). It provides for an air-chamber at the back, in which the fresh air is heated before it enters the room. If the fire-place be built in an external wall, the inlet for fresh air may be situated immediately behind, but if in an inner wall, a channel communicating with the external air by perforated bricks or gratings, and passing beneath the flooring or behind the skirting, must be laid. On the back of the stove broad iron flanges are cast, so as to present as large a heating surface as possible. These project backwards into the chamber, and this heating surface is further supplemented by the smoke flue, also of iron, which passes through the chamber, and is made continuous with the chimney. The fresh air heated in this manner enters the room by a louvred opening situated between the fire-place and ceiling, or by two such openings, one at either side of the chimney-breast. The grate itself is so constructed that the greatest amount of obtainable reflected heat is given off, and a more perfect combustion of the smoke effected than with an ordinary grate. The stoves are of different designs and sizes, to suit existing chimney-openings and different sized rooms. They have the same cheerful aspect as the ordinary grate, and produce the same degree of warmth in a room with a third of the quantity of fuel; besides, the temperature of the room is much more equable, and unpleasant draughts of cold air are avoided. In Boyle's ventilating grates, which are perhaps more ornamental, the heated air enters the room through a transverse fenestrated opening extending along the top of the grate. In Shorland's patent Manchester grate, which has been highly spoken of, the warmed outside air is made to enter the room through the shelf of the chimney-piece, and by means of special flues it can be conveyed to bedrooms above. Kitchen

stoves have also been constructed on the same principle, and stoves suited for the centre of halls or wards. The smoke-flue of the latter is made to pass out under the flooring, and inside the fresh-air entrance channel, thus supplying a larger heating area for the entering air. The terra-cotta stoves in Herbert Hospital are of this description. But so many ventilating grates have lately been patented that it would be impossible to give any selected list here. Indeed, with regard to grates, kitcheners, and stoves of all kinds which have been specially commended, the reader is referred to the list of the awards given at the Smoke Abatement Exhibition held at South Kensington. (See *Sanitary Record,* August 15, 1882.)

At this exhibition and at the subsequent International Health Exhibition in 1884 numerous grates were shown, which, in addition to their warming properties, were specially devised to economise fuel and consume their own smoke. The vast majority of grates at present in use are constructed on wrong principles by allowing the cold air to rush through the centre of the fire, thus causing rapid consumption of the fuel, and sending the warmth along with the half-burned gases up the chimney. In order to economise fuel it is necessary to cut off this stream of cold air which passes through the bottom of the grate, an arrangement which is carried out in all grates made with solid fire-brick bottoms, after the pattern of the Parson's, Abbotsford, or Kyrle grates. But, as Mr. Pridgin Teale has so clearly pointed out in a small brochure on economy of coal, the same results can be obtained by closing up the open chamber under the grate by means of a close-fitting shield or door, which can be made by any blacksmith or ironmonger. Indeed, according to Mr. Teale's experiments, grates provided with these shields, or "economisers" as he calls them, answer better than those with solid fire-brick bottoms, and he

gives some excellent rules regarding the construction or alteration of fire-places, which are of such general application that they may be fitly quoted here:—"1. Use as much fire-brick and as little iron as possible. 2. The back and sides of the fire-place should be made of fire-brick. 3. The back of the fire-place should lean or arch over the fire. 4. The bottom of the fire or grating should be deep from before backwards (not less than 9 inches for a small room). 5. The slits in the grating should be narrow. 6. The bars in front should be narrow. 7. The chamber beneath the fire should be closed in front by a shield or 'economiser.' In lighting the fire it is well to draw away the economiser for a short time until the fire is well started. If an 'economiser' is not used, considerable saving of fuel may be effected by having an iron plate made to fit the bottom of the grate and laid on the bars."

Great improvements, too, have recently been made in close stoves and kitcheners, both as regards economy of fuel and smoke abatement, while gas-cooking stoves are coming into much more general use, especially during the summer months. There are also several very admirable gas-ventilating stoves, such as the well-known Calorigen stove invented by Mr. George, and Dr. Bond's Euthermic Ventilating Stove, manufactured by the Gloucester Sanitary and Economic Association. For warming and ventilating bedrooms, the Thermic Ventilator devised by Mr. Lawson Tait of Birmingham may be mentioned as a cheap and effective arrangement.

The great objection to many of the commoner kinds of stoves depends on the fact that their over-heated surfaces dry the air to a very unwholesome extent, even when the fresh air is conveyed by a special entrance channel. Numbers of them, however, are put up without providing any such channel, so that the air not only be-

comes dry and burnt, but exceedingly close and unpleasant. Evaporating dishes placed on the stoves will assist in remedying this evil, or painting the iron surface with a solution of silica, as suggested by Dr. Bond; but it is much preferable, and in the long run more economical, to have a good ventilating stove erected in the first instance.

For all ventilating stoves it is necessary that the fresh-air channels should be removed from all sources of contamination, such as drains, closets, stables, etc.; and it is advisable to protect the external openings by perforated bricks or gratings. The size of the stove and the sectional area of the air-channel must of course be regulated by the size of the space which is to be warmed and ventilated.

Stove smoke-flues may be either ascending or descending, but in the latter case a pilot-stove or rarefier ought to be fixed at the base of the upright chimney which receives the flue, otherwise the draught may prove faulty. Soot doors should be provided at all the bends, wherever practicable.

With the ordinary grate the ventilation of a room may be very greatly improved by providing an entrance into the chimney near the ceiling, and to prevent reflux of smoke, the opening should be valved, as in Dr. Arnott's chimney ventilator, or Crossley's noiseless ventilators. One or more openings for the entrance of fresh air could be obtained by inserting perforated bricks or Sheringham valves in the outer walls, also near the ceiling, but at a distance from the fire-place, or by adopting one or other of the several contrivances mentioned in the previous section. Indeed, the mistake which is common to the great majority of houses consists in providing an outlet, generally the chimney, and neglecting to provide an inlet, whereas the essential principle of ventilating demands that there shall be at least two openings, one of which

shall act as an inlet, and the other as an outlet, according to circumstances.

Instead of an opening leading directly into the chimney for an outlet, a much better plan is to have a flue running alongside the chimney, the entrance to the flue being situated near the ceiling. The hot air in the chimney warms the flue, and there is thus a constant upward current established without any risk of reflux of smoke. But this is an arrangement which can only be attended to in the original plan of a building; it cannot be applied as an improvement afterwards.

Some architects recommend that all the rooms in a well-constructed house should be supplied with warm air from the hall and staircase. In Mr. Ritchie's plan the air is heated to about 70° Fahr., and enters the various rooms through longitudinal openings over each door. After being diffused through the rooms, it then passes up the chimneys and through flues reaching from the ceiling to the wall-heads under the roof.

Somewhat similar to this is the plan devised some time ago by Drs. Drysdale and Hayward of Liverpool. The fresh air, warmed by a coil of hot-water pipes in the basement, is admitted into a central hall containing the staircase and separate landings, from which it enters the several rooms by suitable openings supplied by valves, and from these again it is conveyed to special outlets in the ceilings, converging to a foul-air chamber under the roof. From this foul-air chamber there is a downcast shaft communicating with the kitchen fire, which is thus made to act as an extraction-furnace.

With regard to these and other complicated methods of house-ventilation, it has to be pointed out that no system is to be commended which dispenses with the opening of windows occasionally in order to secure thorough perflation. No doubt, it adds greatly to the

comfort of a house if the air in the hall is warmed, and it will also add greatly to comfort if the air thus warmed can be introduced into the rooms by suitable openings; but even in winter the windows should be thrown open for a brief period at least every morning, and in summer, window-ventilation should be chiefly depended on, and the entrance-hall, if louvred in the roof, would act as an extraction-shaft.

Large and compact buildings, such as hospitals, asylums, and prisons, can be very efficiently warmed and ventilated by a suitable arrangement of steam-coils or hot-water pipes. The fresh air, as it enters through openings properly distributed throughout the building, is warmed by passing over the pipes, while the vitiated air may be extracted by means of other coils of heated pipes situated in extraction-shafts.

Another mode of ventilation by extraction, and one which is frequently used in prisons, consists in having a large foul-air extraction shaft or shafts, heated by a furnace at the bottom, and into which foul-air flues, leading from all parts of the building, are conducted. The workmanship in this case requires to be very perfect, so as to prevent any large currents of air reaching the shaft except through the flues.

By a combination of these two methods—viz. heating the fresh air before entering by hot-water pipes, and securing the removal of the vitiated air by flues leading to furnace-shafts—the largest buildings can be well warmed and ventilated. If necessary, the hot-water pipes may be made to pass through shallow basins of water, to ensure a sufficiency of moisture in the contained air.

As an instance of the successful ventilation of a large hall, which until recently was notorious for its defects in this respect, the improvements may here be mentioned which were carried out in 1882 in the Council Chamber of the Guildhall, London, by Messrs. Boyle and Son, the

well-known ventilating engineers. The conditions under which they undertook to remedy the existing defects were of the most stringent nature, but they were carried out so completely as to meet the approval not only of the committee appointed to enforce them, but of numbers of well-known writers on ventilation, who were invited to test and examine the working of the system, which is, in the main, automatic. Briefly stated, the plan adopted by Messrs. Boyle was as follows:—For the inlet of fresh air, sixteen vertical ventilating-shafts, projecting only about three inches from the walls, were placed in various parts of the chamber, and with outlets at different altitudes, so as to admit the fresh air at different heights. These shafts are fitted with patent heaters, which are warmed by means of a gas jet fixed by the side of each shaft and enclosed in a metal casing, so that the temperature of the incoming air can be regulated by raising or lowering the gas jets. The heat imparted by each gas jet is carried up inside the shaft to a certain height by a tube, which then crosses it, and is brought down zigzag fashion to a small receptacle at the bottom, which receives the water of condensation, and transmits it, along with the other products of combustion, through a small tube to the outside. By this means a constantly induced current of fresh air can be kept up in all the shafts, whatever be the temperature of the outside air; while the vitiated inside air is extracted by shafts springing from various parts of the ceiling through roseate perforations, and converging to patent exhaust cowls on the roof.

Almost all large mines are ventilated on this principle of extraction. By means of a furnace at the bottom of the upshaft, the air is drawn down another shaft and made to traverse the various galleries by an arrangement of partitions and double doors. In well-ventilated mines as much as 2000 cubic feet of air per head

per hour can be supplied in this way, and in fire-damp mines, 6000.

In men-of-war and steam-vessels an iron casing surrounding the bottom of the funnel and upper part of the boilers is utilised as an extraction-shaft. When the fires are kept burning, so great is the current which rushes up this shaft, that the air can be drawn through the hatchways from all parts of the vessel, and even the hold and timbers ventilated.

In theatres, and other buildings of a similar description, the chandeliers should always be employed to extract the vitiated air. According to the experiments of General Morin, one cubic foot of gas can be utilised so as to cause the discharge of 1000 cubic feet of air. Apart, therefore, from the great advantages arising from the direct removal of the products of combustion, the aid to ventilation furnished by the extractive power of gas-lights merits special attention, for as a common gas-burner will burn nearly 3 feet of gas per hour, its extractive power could thus be utilised to remove nearly 3000 cubic feet of vitiated air during the same period. Where a large flood of light is required, the "sun-burner" acts very efficiently in this way, and for smaller rooms or workshops, the "box-top sun-burner" is found to answer very well. The new "ventilating globe-light" ought also to be mentioned amongst the latest improvements in this direction. It is so arranged that so soon as the gas is lighted, an upward current is produced in the main tube, and as this becomes heated, the air in the surrounding tube near the ceiling becomes rarefied and set in motion. In this way the heated air in both tubes is carried to a special shaft or to the chimney, thereby securing the removal of the products of combustion, and a steady current outwards of the vitiated air in the room. Tubes of tin or zinc placed over common burners, and communicating with the

external air, or leading into the chimney, would answer the same purpose where ornamentation can be dispensed with; but in either case it is necessary that the room should be well ventilated, otherwise the extractive force of the fire will most likely occasion a down-draught through the ventilating tubes.

Extraction by means of a steam jet, and extraction by a fan or screw, are now generally abandoned on the large scale. What is known as the Archimedean-screw ventilator, however, has been lately recommended for small air-shafts, and has also been applied to large factories, where it may be worked by hand or steam power. In mines, the fan has been made to extract as much as 45,000 cubic feet of air per minute.

The system of ventilation by propulsion was first introduced by Dr. Desaguliers in 1734. It is carried on by means of a fan enclosed in a box, which can be worked by hand, horse, water, or steam power. The air enters through an opening in the centre of the box, and is thrown by the revolving fan into a conduit which communicates by proper channels with the different parts of the building. In France and America the fan is employed in the ventilation of several of the large hospitals, the air being forced into a basement chamber, where it is heated before it enters the wards. This is known as Van Hecke's system. In this country St. George's Hall, Liverpool, may be cited as affording an example of ventilation by propulsion on the large scale. The air is taken from the basement, and washed by being passed through a thin film of water thrown up by a fountain. It is then passed in cold weather into vessels for the purpose of being warmed, and in which it can be moistened by a steam jet whenever the difference between the dry and wet bulb exceeds 5°, and finally, it is propelled along different channels into the hall. In summer,

the air in the conduits is cooled by the evaporation of water.

Various other methods of propulsion have been tried, such as the bellows arrangement proposed by Dr. Hales, or the gasometer pump worked by hydraulic pressure planned by Dr. Arnott, but mostly all of them have fallen into disuse.

Concerning the relative merits of these two systems of ventilation, viz. extraction and propulsion, the balance of evidence is most decidedly in favour of the former, as regards cost, efficiency, and stability. In either system, natural ventilation plays a most important part, whether it be taken into consideration in the construction of buildings or not; and hence every facility should be afforded for its operation, without at the same time permitting its disadvantages to take effect. For dwelling-houses, workhouses, asylums, barracks, and hospitals, there is no doubt that natural ventilation, aided by the extractive power of the heat generated in warming and lighting, is by far the best system. On the other hand, buildings such as prisons, theatres, etc., must be ventilated by mechanical appliances, and experience has proved that these should provide for ventilation by extraction.

General Considerations.—With regard to the relative position of inlets and outlets, there seems to be some difference of opinion. Theoretically, the inlets for the fresh air should be situated near the floor, and the outlets near the ceiling; but the question of temperature interferes with the practical application of this rule. If the air is not warmed before entering, the inlets should be at least nine or ten feet from the floor, or close to the ceiling, and so constructed that the cold air will impinge against the roof, and fall gently into the room. They should slope upwards to prevent entrance of rain, and should communicate with the external air by means of perforated

bricks or gratings so as to divide the entering current and break its force. With vertical tubes such as Tobin's or Shorland's tubes, the inlets need only reach about six feet from the floor. Sliding covers, valves, or rotatory discs might also be provided, in order that they may be partially or totally closed during rough weather. If the air is warmed before entering, the inlets may be situated, and generally are situated, near the level of the floor. But in either case it is essential that they should be equally distributed throughout the room, to ensure proper diffusion, and that the structural arrangements should permit of their being readily cleaned out, because dirt is sure to accumulate.

The outlets, as already stated, are best situated in or near the ceiling, not only because air vitiated by respiration tends to ascend on account of its lessened density, but because experiment proves that, given the same extractive power and the same size of outlet, a greater volume of air passes up a flue whose orifice is near the ceiling than up one whose orifice is near the floor. Inlets and outlets should not be situated near each other, otherwise the entering air will be extracted without being first diffused throughout the room.

Outlet tubes, or foul-air flues, as they are generally called, should be smooth, so as not to impede the current of air by friction, and in systems of ventilation by extraction they should be air-tight. When built in external walls and only plastered, I have frequently satisfied myself by experiment that the outside air finds its way into the flue and sometimes in such volume that though there may be a good current issuing from the top, scarcely any current can be detected entering it at the bottom. I have also found that when the wind beats strongly against the side of a building, with foul-air flues situated in the outer walls, a current of air may actually be issuing from both

orifices at the same time. The experiments of Pettenkofer explain how readily such an occurrence may take place, for he has proved beyond doubt that even under ordinary atmospheric conditions, a very considerable interchange of gases takes place through common dry-plastered walls, and indeed, as the sick often experience, very perceptible draughts find their way through outer walls when a stiff breeze is blowing. All foul-air flues, therefore, should be as nearly air-tight as possible, and if they were made of metal tubing, or of glazed earthenware, they would not only satisfy this condition, but would serve greatly to lessen the friction, which is such an impediment to ready extraction through common plastered flues. It is further evident that, when it can be avoided, they should not be situated in external walls, because in cold weather the air becomes cooled as it ascends, and unless the extractive power is very considerable, the increased weight of the column of air by loss of heat will counteract the extractive force. Where there is no system of artificial extraction, it thus often happens that outlets become inlets, and inlets outlets.

Another very important point remains to be considered, namely, the sectional area of the inlets and outlets. As atmospheric conditions are constantly varying, it is obviously impossible to fix upon any size which will meet every requirement. The only alternative, therefore, is to provide an area that will suit the majority of cases, and which will be capable of being increased or diminished according to circumstances. Dr. Parkes has pointed out that in this country a size of 24 square inches for inlet per head, and the same for outlet, is the one best adapted to meet common conditions. Theoretically, the sectional area of the outlets should vary according to the height of the foul-air flues, and the Barrack Commissioners have accordingly recommended that it should amount to 1

square inch for every 50 cubic feet of space for upper floors, to 1 square inch for every 55 cubic feet for rooms below, and to 1 square inch for every 60 cubic feet for rooms on the ground-floor, in buildings of three stories. Practically, however, these nice distinctions may be disregarded, because the friction in long flues lessens very considerably the advantage in extractive power attaching to them, on account of their greater height, and also because, in the great majority of cases, the column of air in the flue increases in density the higher the flue. In prisons, where the cubic space per head is comparatively small, the sectional area of inlets and outlets should be at least 20 square inches per head. In barracks, hospitals, etc., the separate inlets should not exceed 1 square foot, otherwise the entering air will be badly distributed.

More precise details with regard to the ventilation of hospitals will be given in the chapter on hospitals.

CHAPTER V.

EXAMINATION OF AIR AND VENTILATION

A DETAILED examination of the sufficiency of ventilation in any particular case will embrace the following inquiries:—

1. The arrangements as regards cubic space, the relative size and position of inlets and outlets, the distribution of the air, and the amount of fresh air supplied.
2. The examination of the contained air by the senses.
3. Chemical examination of the contained air.
4. Microscopical examination of suspended impurities.
5. Examination as regards temperature, moisture, etc.

SECTION I.—EXAMINATION AS REGARDS VENTILATING ARRANGEMENTS.

The measurement of the cubic space is a simple question of mensuration, but corrections must be made for furniture, bedding, etc., and for inequalities in the contour of the space to be examined. For instance, the displacement caused by solid projections into the room must be deducted, and the cubic contents of open recesses added. The allowance for each bedstead and bedding may be estimated at 10 cubic feet, and for the space occupied by the body of each adult person at 3 cubic feet.

After the exact cubic space per head has been ascertained, the next points to be inquired into are the relative position and size of inlets and outlets. Perforated bricks and gratings can be approximately estimated, as regards

their total open sectional area, by taking their actual superficial area, and calculating the relative size of the interstices. Inlets should be inspected as regards their freedom from accumulation of dust, etc., and outlets as regards the presence of any impediments to the ready exit of the vitiated air. Where there are open fire-places, the sectional area of the smoke-flue must also be ascertained. The existence or otherwise of unpleasant draughts, and the relative position of doors and windows, and how far they assist in the ventilation of the room, are other items which must not escape notice. If the system of ventilation is artificial, it should be examined in all its details, and in this examination great assistance will be derived from inspecting the architect's plans, whenever they can be procured.

The directions of air-currents in a room can be ascertained by means of the smoke from smouldering cotton velvet, fibres of floss-silk, small pieces of feather, small balloons filled with hydrogen gas, etc. The flame of a candle is often used for the same purpose, but it is of no value when the currents are delicate, because it is unaffected by them, but is of considerable service in showing whether air is entering or issuing through any opening. Very frequently, as has already been pointed out, openings that are meant to be inlets act as outlets, and *vice versa*, or the movement of air in them may be unstable, intermittent, and reversed in its action, now entering and now issuing through the same opening.

All these points, and others which may arise from peculiarities of structural arrangement, must be carefully inquired into, and the various measurements and observations noted down as they are made. When the ventilation is intended to be carried on independently of open doors and windows, these should be closed during the examination.

In determining the rate of movement through the various openings, an instrument called an anemometer is generally used. This may briefly be described as a miniature windmill. The little sails, driven by the air-current, set in motion a series of small cogged wheels, which move an index or indices on a dial-plate. The velocity of the current can thus be read off for a given time, in the same way as the amount of gas which has been consumed is ascertained from a gas-meter. A very beautiful and delicate instrument of this description has been constructed by Mr. Casella of Hatton Garden, with indices on the dial-plate indicating the velocity of an air-current in feet, hundreds of feet, thousands, etc., up to millions. By moving a catch, the machinery may be stopped at any moment of time. With this instrument, the rate of movement of air through any opening is readily, and, as a rule, accurately ascertained. Before using it, the index indicating feet in units should be set at zero, and the relative position of as many of the other indices as may be deemed necessary noted down. When the instrument is placed in the air-current, time is called, and the catch moved to set the machinery free. At the end of one minute, two minutes, etc., according to the length of period of observation, time is again called, and the machinery immediately stopped by means of the catch. The linear dimension of the current is then read off, and if this is multiplied by the sectional area of the opening, the volume of air which has passed through in a given time can be easily calculated in cubic feet. When the instrument is placed in a tube or shaft, it should be put well in, but not quite in the centre, because the velocity of the current in the centre is greater than at the sides of the tube. Should the shaft be large, the rate of movement ought to be taken at different parts, and the average ascertained. So also, when the rate of movement is

irregular, several observations should be made, and the average of the whole of them will give the approximate velocity of the current. If placed in a tube whose sectional area exceeds but very little the space occupied by the revolving sails, the results cannot be depended on; and when placed at the entrance of a tube, for example, against a perforated air-brick or grating, the velocity of the current indicated by the anemometer is considerably less than what exists in the tube. In these cases the instrument should be exactly fitted into an opening in a box, large enough to cover completely the mouth of the tube, by which means the whole of the air passing through the tube may be made to pass through the opening in the box.

The amount of air found to be issuing up chimneys or other outlets is a far more reliable index of the fresh-air supply than the amount actually ascertained to be entering through the inlets; and indeed the fresh-air supply can only be fairly estimated in this way. As already stated, the air enters through every chink and cranny, and in dry plastered walls may enter, to no slight extent, through the walls themselves. Hence the difference between the amount of air found to be entering through the regular fresh-air inlets and that found to be issuing through the outlets is often very great. In a ward containing 15 beds, with one door, eight windows, and four inlets for fresh air, I have found that while only 880 cubic feet of fresh air were entering through the inlets per bed per hour, as much as 3150 were found to be issuing up the two chimneys and the three extraction-flues of the ward. During the experiments the door and windows were shut, and brisk fires kept burning in the two ventilating fire-places. The large amount, therefore, of 2270 cubic feet per bed per hour entered through chinks in the window-frames, and beneath and around

the closed door. Very probably, in this instance, a considerable amount was also drawn, by the extractive force of the chimneys and flues, through the walls, inasmuch as they were built of brick, and were only whitewashed and not plastered.

When an examination of the respired air itself is intended, a suitable time must be selected, during which all the conditions of the efficiency of the ventilation, in any given instance, can be fairly put to the test. Take a hospital ward, for example. It is necessary that all the beds should be occupied, that windows and doors be kept shut, if ventilation is intended to be effectually carried on without them, and that an hour should be selected in the night-time when the greatest accumulation of impurities is likely to occur. Any hour between midnight and 5 A.M. would meet this condition in most cases. In order to make the examination as complete in detail as possible, it is necessary to have a wet and dry bulb thermometer placed outside some time previously, and several others fixed at different positions in the ward. The outside and inside temperature can thus be compared, and the relative hygrometricity of the air indoors and outdoors ascertained. If the barometer is read off at the same time, and the state of the weather recorded, all the meteorological data are obtained which are usually considered necessary for a full and exhaustive report.

Section II.—The Examination of the Contained Air by the Senses.

With a little practice, this method of examination gives tolerably reliable results; but it is necessary that one should remain for some short time in the open air, before entering the ward or room to be examined, otherwise the sense of smell is likely to be blunted and unable

to appreciate the degree of closeness or foulness. One of the terms, "not close," "rather close," "close," "very close," "foul," "very foul and offensive," will indicate, with sufficient accuracy, the degree of perceptible impurity in the majority of cases. The following selections from Dr. de Chaumont's experiments show how closely the sensations accord with the different degrees of impurity indicated by the percentage of carbonic acid:—

At ·1408 per cent.		Extremely close and unpleasant.	At ·0843 per cent.		Not very foul.
,, ·1090	,,	Extremely close.	,, ·0804	,,	Close.
,, ·0962	,,	Very close.	,, ·0658	,,	Not very close.
,, ·0921	,,	Close.	,, ·0568	,,	Not close.

Section III.—Chemical Examination.

1. *Carbonic Acid.*—In the chemical examination of respired air, the chief point to be determined is the amount of carbonic acid per 1000 volumes. Pettenkofer's method is the one most generally adopted, because it is alike accurate and easy of application. For the analysis, which is volumetric, French weights and measures are used. The following apparatus and solutions are also required.

(1.) Two or more glass jars, each capable of holding 4000 to 6000 centimetre cubes, and fitted with india-rubber caps.

(2.) A Mohr's burette, graduated into centimetre cubes and tenths, fitted with pinch-cock, and large enough to hold 50 or 100 centimetre cubes.

(3.) A narrow glass measure, marked to measure 30 and 60 centimetre cubes exactly.

(4.) A pair of bellows or a bellows-pump.

(5.) Turmeric paper specially prepared. (Turmeric powder should be boiled in alcohol, and ordinary filtering paper steeped in it, then washed and dried.)

(6.) Pure clean lime water. (Both Dr. Angus Smith and lately Pettenkofer prefer baryta water, but I follow in my description the plan pursued by Drs. Parkes and de Chaumont, according to which my own analyses have been made.)

(7.) A solution of crystallised oxalic acid, 2·25 grammes to the litre of distilled water.

The capacity of the glass jars must be accurately determined by means of a litre measure graduated into centimetre cubes, and it is convenient to affix the cubic contents, expressed in centimetre cubes, to each jar. Before being used it is necessary that the jars should be perfectly clean and dry.

The analysis depends on the relative degree of causticity of the lime water before and after it has absorbed the carbonic acid contained in the sample of air to be examined. Thus 1 cubic centimetre of the above solution of oxalic acid exactly neutralises 1 milligramme (·001 gramme) of lime; and hence the amount of lime contained in a given quantity of lime water can be readily determined by adding the solution until the point of neutralisation is reached. The amount of oxalic acid solution required for neutralisation expresses the causticity of the lime water. If now the causticity of the lime water is known before and after it has absorbed the carbonic acid in the air contained in the glass jar, the difference will give the amount of lime in milligrammes which has united with the carbonic acid, and the amount of the latter is obtained by calculating according to the atomic weights.

The amount of neutralisation is determined by means of the turmeric paper. The test solution of oxalic acid should be run into the measured quantity of lime water from the burette, and the mixture constantly stirred with a glass rod. Every now and again a small drop of the

mixture is conveyed on the tip of the rod to the turmeric paper, and one can readily judge by the tint of the stain when the point of neutralisation is approached. With pure lime water the stain produced is an intense dark brown, and as the oxalic acid solution is added, it becomes gradually paler on each application, until at last the centre of the stain is not tinted, and the margin alone appears as a delicate brown ring. The solution should now be carefully added drop by drop, and when the tint of the ring also disappears, the point of neutralisation has been reached.

In making a single analysis it is advisable to use two jars, because otherwise a repetition of the experiment would not be possible were it required. Under ordinary circumstances, however, as many analyses can be made as there are jars used for collecting samples of the air from different parts of the same room or building. The air to be examined is forced into the jars by means of a pair of bellows, and, by a suitable arrangement of tubing connected with the bellows, it can be pumped into them from any part of the room. In the case of small occupied spaces, such as prison cells, when it is not desirable to disturb the ventilation by opening the door, the contained air can in this way be pumped into the jars through any opening, such as the inspection hole in the door,—care being taken that the tubing and its connection with the bellows are perfectly air-tight, and that the bellows-valve acts efficiently.

Instead of bellows, a bellows-pump may be used, but in either case the nozzle should be long enough to reach the bottom of the jar. Either method answers very well, provided that care be taken that the jar is really filled with the air to be examined.

After the jar has been filled, 60 cubic centimetres of lime water are introduced, and the mouth of the jar closed

by a tight-fitting india-rubber cap. If tubing has been used to convey the air from a distant part of the room, or from a small inhabited place without entering it, it is necessary that this part of the experiment should be performed rapidly, in order to prevent escape by diffusion, and therefore the measured quantity of lime water should be ready to be poured into the jar whenever the nozzle of the bellows is withdrawn. The jar is then well shaken, so that the lime water is made to wash the contained air thoroughly, and afterwards is left to stand for a period of not less than six or eight hours, and not more than twenty-four. 60 cubic centimetres are introduced, in order that 30 may be taken out for analysis. So much of the lime water adheres to the sides of the jar that the whole amount introduced cannot be poured out; and hence, if a repetition of the experiment is necessary, another jar must be used.

In making the analysis, 30 cubic centimetres of the lime water which has been employed are poured into a mixing jar, and its causticity determined as above described by the test solution. Then 30 cubic centimetres are taken from the jar, and the causticity also determined. The causticity of the lime water is found to vary from 34 to 41, according to its strength: in other words, from 34 to 41 cubic centimetres of the oxalic acid solution will be required for neutralisation, while the causticity of the lime water in the jar will be lessened in proportion to the amount of carbonic acid in the contained air. The difference between the first and second operations is doubled to account for the 30 cubic centimetres left in the jar, and the product gives the amount of lime which has combined with the carbonic acid. The amount of the latter, as already observed, is obtained by converting weight into measure according to the atomic weights, and in one sum the factor is found to be ·39521. The capacity of

the jar being known, and a deduction of 60 cubic centimetres made for the space occupied by the lime water, the amount of carbonic acid becomes a question of simple proportion. Thus, to take an example—Suppose the causticity of 30 cubic centimetres of the lime water is 39·5, and the causticity of the lime water in the jar is 33·5; suppose also that the capacity of the jar is 5060 cubic centimetres; then, to find the ratio of carbonic acid per 1000 volumes, that is per 1000 cubic centimetres, the problem is as follows:—

$(5060 - 60) : 1000 :: [(39{\cdot}5 - 33{\cdot}5) \times 2 \times {\cdot}39521] : X$

therefore $X = \frac{6 \times {\cdot}79042}{5} = {\cdot}948$ carbonic acid per 1000 volumes.

It will thus be seen that the calculations may be simplified by adopting the following rule:—Multiply the difference between the causticity of the lime water, before and after it has been placed in the jar, by 790, and divide this sum by the number of centimetre cubes contained by the jar, *minus* 60. The result will be the ratio of carbonic acid per 1000 volumes.

But a certain correction must be made for temperature, according as it is above or below the standard of 62° Fahr. As the co-efficient of expansion of air is ·0020361 for every degree Fahr., the rule for correction may be stated with sufficient accuracy thus:—For every 5° above 62° add 1 per cent to the amount of carbonic acid calculated as above, and deduct the same percentage for every 5° below 62°.

If the place of observation is much above the sea-level, a correction must also be made for the difference of atmospheric pressure. The standard barometric pressure being 30, the formula for this correction is as follows:—

30 : (observed height of barometer) : : capacity of jar : Z.

The result expressed by Z is substituted for the actual capacity of the jar in the calculation for carbonic acid.

Amongst various popular tests for the estimation of the carbonic acid in air vitiated by respiration, the following, proposed by Dr. Angus Smith, is worthy of notice, because it does not require skilled manipulation, nor is it hampered with troublesome measurements or calculations. The method is based upon the fact that the amount of carbonic acid in a given quantity of air will not produce a precipitate in a certain given quantity of lime water, unless the carbonic acid is in excess. This will be better understood by comparing the different columns in the subjoined table, which is taken from Dr. Smith's work on *Air and Rain* :—

EASIEST PROPOSED HOUSEHOLD METHOD.

TABLE.—*To be used when the point of observation is "No precipitate."* Half an ounce of lime water containing ·0195 gramme lime.

Air at 0° C. and 760 Millim's bar.

Carbonic acid in the air. Per cent.	Volume of air in cubic centimetres.	Size of bottle in cubic centimetres.	Size of bottle in ounces avoirdupois.
·03	571	584	20·63
·04	428	443	15·60
·05	342	356	12·58
·06	285	299	10·57
·07	245	259	9·13
·08	214	228	8·05
·09	190	204	7·21
·10	171	185	6·54
·11	156	170	6·00
·12	143	157	5·53
·13	132	146	5·15
·14	123	137	4·82
·15	114	128	4·53
·20	86	100	3·52
·25	69	83	2·92
·30	57	71	2·51

Columns 1 and 2 give the ratio of carbonic acid in the quantity of air which will produce no precipitate in

half an ounce lime water; column 3 is the same as column 2, with the addition of 14·16 cubic centimetres, or half an ounce, to give the corresponding size of bottle; and column 4 gives the size of bottle in ounces avoirdupois. It will thus be seen that different-sized bottles containing half an ounce of lime water will indicate approximately the ratio of carbonic acid in the air contained in them, by giving no precipitate when the bottle is well shaken. Thus, if a bottle of $10\frac{1}{2}$ oz. is used, and there is no precipitate, it will indicate that the ratio of carbonic acid does not exceed ·06 per cent; or if one of 8 oz. is used, and there is also no precipitate, it will indicate that the ratio does not exceed ·08, and so on. Dr. Smith says that "the lime water may be prepared of the same constant strength so closely that we may neglect the difference. Burnt lime is slaked with water and dissolved by shaking. It is then kept in a bottle to stand till it is clear. The bottle or bottles used should be wide-mouthed, so that they can be readily cleaned and dried, and the air to be examined may be made to enter them by inhaling the air contained in them through a glass or caoutchouc tube, care being taken not to breathe into the bottle."

As a practical application of this method, which can be practised by any one, Dr. Smith proposes the following rule:—"Let us keep our rooms so that the air gives no precipitate when a $10\frac{1}{2}$ oz. bottleful is shaken with half an ounce of clear lime water."

2. *Organic Impurities.*—To obtain an approximate estimate of the organic impurities, the air may be drawn through, or washed, in a very dilute solution of potassium permanganate of known strength. The result is stated in the number of cubic feet of air which it takes to decolourise ·001 gramme of the potassium permanganate in solution. The method pursued by Dr. Angus Smith is somewhat different from this. He takes about 30 cubic centimetres

of pure water, and adds to it a small amount of known solution of the potassium permanganate. This solution is shaken up with the air in the bottle; the air is then drawn out by a bellows-pump, and another bottleful washed, and so on until the whole colour is removed, or a sufficient amount to enable him to test the remainder, so as to be able to estimate the difference. The actual amount of oxygen taken is then calculated, and the results stated in grains per million cubic feet of air.

3. *Ammonia.*—The estimation of the ammonia, organic and albuminoid, is a still more delicate and difficult process. The water used for washing the air must be perfectly pure, and should therefore be boiled with soda or potash before distillation. From 30 to 50 cubic centimetres are then introduced into a bottle of about 2000 cubic centimetres, and the washing of successive bottlefuls of the air to be examined is continued until the water is sufficiently charged with impurities. A more exact method is to draw the air through distilled water by means of an aspirator of known dimensions, which, whether charged once or several times, will indicate accurately the amount of air whose impurities are to be tested. The testing afterwards is the same as that proposed by Messrs. Wanklyn, Chapman, and Smith, for organic impurities in water, and the results are stated in grains per million cubic feet of air.

For further information concerning these methods of analysis, and for an account of numerous valuable experiments, see Dr. Angus Smith's work already quoted, and Dr. Fox's work on the *Sanitary Examinations of Water, Air, and Food.*

Section IV.—Microscopical Examination.

Suspended matters contained in the air may be collected by drawing the air through distilled water by means

of an aspirator, by washing the air in distilled water, or by employing an instrument called an aeroscope. When either of the first two processes is employed, the suspended matters are merely allowed to subside, and are then removed to a glass slip for examination. The aeroscope invented by Pouchet consists of a funnel-shaped tube, ending in a fine point, beneath which is placed a slip of glass moistened with glycerine. Both glass and tube are enclosed in an air-tight chamber, which is connected by tubing with an aspirator, so that when the stopcock of the aspirator is turned, and the water allowed to escape, the air is drawn through the tube, and impinges against the slip of glass moistened with glycerine, by which the suspended matters are arrested.

Section V.—Examination as regards Temperature and Moisture.

1. *Temperature.*—The various points connected with the temperature of the contained air, such as its equability, sufficiency, etc., are readily ascertained by a judicious distribution of thermometers throughout the space to be examined, and by comparing the outside with the inside temperature. The efficiency of the heating apparatus is of course best tested during very cold weather and in the night time. When open fire-places are used the temperature should be noted at the remote parts of the room, and if the air is heated before entering, it is advisable to take the temperature at the point of delivery, and to ascertain whether it is well diffused or not.

2. *Moisture.*—The amount of watery vapour, or the hygrometricity of the contained air, may be determined by hygrometers such as Daniell's and Regnault's, or by wet and dry bulb thermometers. The latter are the most convenient and reliable, but they should be distributed

some two or three hours before the observations are made. The wet bulb is covered with muslin, over which there is twisted a small skein of cotton, which dips into a little vessel containing either distilled or rain water. The cotton should be boiled in ether, or soaked in a solution of sodium carbonate, to free it from fat, so that the water may readily ascend by the force of capillary attraction.

Unless the air is saturated with moisture, the temperature of the wet bulb is always below the temperature of the dry, and the number of degrees of difference between them varies according to the amount of watery vapour present. This is generally represented in relative terms. For example, the point of complete saturation being assumed to be 100, any degree of dryness may be stated as a percentage of this, and can be conveniently ascertained by reference to the table given on the following page, which has been calculated from Mr. Glaisher's large tables. The table is read by taking the temperature of the dry bulb, and the difference between it and that of the wet bulb, and noting the number given at the intersection of the two columns. This number gives the relative humidity.

The relative humidity of the air out of doors should also be ascertained at the same time, by way of comparison.

In carrying out experiments in ventilation, the hair-hygrometer gives sufficiently accurate results, and possesses a considerable advantage over the dry and wet bulb thermometer in rapidity of indication. It consists of a human hair freed from fat by steeping it in ether or a solution of liquor potassæ, one end of which is fixed, and the other attached to a small needle, and according as the hair becomes shorter or elongates, the needle traverses a graduated scale, and thus indicates the relative humidity.

TABLE *of the Relative Humidity given by the difference between the Dry and Wet Bulb.*

Temperature of the Dry Bulb.	DIFFERENCE BETWEEN THE DRY AND WET BULB.															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	RELATIVE HUMIDITY, SATURATION=100.															
90	100	95	90	85	81	77	73	69	65	62	59	56	53	50	47	44
89	100	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
88	100	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
87	100	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
86	100	95	90	85	80	76	72	68	64	61	58	55	52	49	46	43
85	100	95	90	85	80	76	72	68	64	61	58	55	52	49	46	43
84	100	95	90	85	80	76	72	68	64	60	57	54	51	48	45	43
83	100	95	90	85	80	76	72	68	64	60	57	54	51	48	45	42
82	100	95	90	85	80	76	72	68	64	60	57	54	51	48	45	42
81	100	95	90	85	80	76	72	68	64	60	56	53	50	47	44	41
80	100	95	90	85	80	75	71	67	63	59	56	53	50	47	44	41
79	100	95	90	85	80	75	71	67	63	59	56	53	50	47	44	41
78	100	94	89	84	79	75	71	67	63	59	56	53	50	47	44	41
77	100	94	89	84	79	75	71	67	63	59	56	53	50	47	44	41
76	100	94	89	84	79	75	71	67	63	59	55	52	49	46	43	40
75	100	94	89	84	79	74	70	66	62	58	55	52	49	46	43	40
74	100	94	89	84	79	74	70	66	62	58	55	52	48	45	43	40
73	100	94	89	84	79	74	70	66	62	58	54	51	48	45	42	40
72	100	94	89	84	79	74	69	65	61	57	54	51	48	45	42	39
71	100	94	88	83	78	73	69	65	61	57	53	50	47	44	41	38
70	100	94	88	83	78	73	69	65	61	57	53	50	47	44	41	38
69	100	94	88	83	78	73	68	64	60	56	53	50	47	44	41	38
68	100	94	88	83	78	73	68	64	60	56	52	49	46	43	40	37
67	100	94	88	83	78	73	68	64	60	56	52	49	46	43	40	37
66	100	94	88	83	78	73	68	64	60	56	52	48	45	42	40	37
65	100	94	88	83	78	73	68	63	59	55	51	48	45	42	39	36
64	100	94	88	82	77	72	67	63	59	55	51	48	45	42	39	36
63	100	94	88	82	77	72	67	63	59	55	51	47	44	41	38	35
62	100	94	88	82	77	72	67	62	58	55	50	47	44	41	38	35
61	100	94	88	82	77	72	67	62	58	54	50	47	44	41	38	35
60	100	94	88	82	76	71	66	62	58	54	50	46	43	40	37	34
59	100	94	88	82	76	71	66	61	57	53	49	46	43	40	37	34
58	100	93	87	81	76	71	66	61	57	53	49	46	43	40	37	34
57	100	93	87	81	75	70	65	61	57	53	49	45	42	39	36	33
56	100	93	87	81	75	70	65	60	56	52	48	44	41	38	35	32
55	100	93	87	81	75	70	65	60	56	52	48	44	41	38	35	32
54	100	93	86	80	74	69	64	59	55	51	47	43	40	37	34	31
53	100	93	86	80	74	69	64	59	55	51	47	43	39	36	33	30
52	100	93	86	80	74	69	64	59	54	50	46	42	39	36	33	30
51	100	93	86	80	74	68	63	58	54	50	46	42	38	35	32	29
50	100	93	86	80	74	68	63	58	53	49	45	41	37	34	31	29
49	100	93	86	79	73	67	62	57	53	49	45	41	37	34	31	28
48	100	93	86	79	73	67	62	57	52	48	44	40	36	33	30	
47	100	93	86	79	73	67	61	56	51	47	43	39	36	33	30	
46	100	93	86	79	73	67	61	56	51	47	43	39	35	32	29	
45	100	92	85	78	72	66	60	55	50	46	42	38	34	31	28	
44	100	92	84	78	71	65	59	54	49	45	41	37	34	31	28	
43	100	92	84	78	71	65	59	54	49	45	41	37	34	31	28	
42	100	92	84	78	71	64	59	54	49	44	40	36	34	30	27	
41	100	92	84	77	70	64	58	53	48	43	39	35	31	28		
40	100	92	84	77	69	63	57	52	47	42	38	34	31			
39	100	92	84	77	69	63	57	51	46	42	38	34				
38	100	91	83	75	68	62	56	50	45	41	37					
37	100	91	83	75	68	61	55	49	44	39						
36	100	91	82	74	66	59	53	47	42							
35	100	90	80	72												
34	100	89	79	72												
33	100	89	78	70												
32	100	87	75													

After a time, however, it loses its delicacy, and requires to be readjusted.

In a room well ventilated and warmed the humidity ought to range between 73 and 75 per cent, the temperature should not fall below 60° Fahr., and the carbonic acid, as previously stated, should not exceed ·6 per 1000 volumes.

In the examination of the air contained in the crowded dwellings of the poorer classes, the senses will alone sufficiently indicate the degree of impurity, but in all cases the cubic space per head, and the means of ventilation, should be carefully noted, because otherwise any suggestions as regards improvements will at the best be haphazard, and possibly ill-advised. The amount of cubic space obtainable in the houses of the poor, and especially in rural districts, will be more fully discussed in Chapters IX. and XVII.

CHAPTER VI.

WATER

Section I.—Sources.

All supplies of fresh water are derived from the condensation of the aqueous vapour contained in the atmosphere. Whether this falls to the earth in the form of rain or snow, a certain portion of it runs off the surface and gravitates towards the sea; another portion sinks into the soil, and, passing through strata which are more or less porous, or through fissures in rocks, again reappears in springs and wells; a third portion is evaporated where it falls; and the remainder becomes absorbed in the chemical composition of minerals, or is utilised in the processes of growth and decay of animal and vegetable life.

The rainfall which flows on the surface collects in streams, lakes, and rivers, according to the conformation of the ground, while the water flowing under ground oozes to the surface either imperceptibly or in springs, and eventually unites with the surface water in its accumulation in lakes, or in its onward progress towards the sea.

The immediate sources of water-supply may therefore be classified as rain water and water from springs, wells, rivers, or lakes.

1. *Rain Water.*—Rain water is highly aerated, and, when uncontaminated by the receiving surface or by air-impurities, is healthy and pleasant. But frequently,

according to the analyses of the Rivers Pollution Commissioners, it contains a large amount of organic matter, and in this country is usually far less pure than water derived from deep wells and springs. This is not to be wondered at when we consider that the atmosphere in a thickly populated country like Great Britain becomes the recipient of vast quantities of excremental dust and effluvia, of smoke particles, and the products of animal and vegetable decay. It is therefore seldom stored on premises except for washing purposes; but in Venice and many other Continental cities it is collected in underground reservoirs, and constitutes almost the sole source of fresh-water supply to the inhabitants. It is usually collected from the roofs of houses, and occasionally from paved or cemented ground. In hilly districts with deep ravines it may be stored by carrying an embankment across a valley, or, in level districts, by digging a series of open trenches leading to a tank or reservoir.

The amount of water derivable from the rainfall in given cases is readily ascertained, if the mean annual rainfall of the district is known, and the dimensions of the receiving area are obtained. Thus, when the roofs of houses constitute the receiving area, the transverse section of the buildings will be one factor, and the mean annual rainfall the other. It has been estimated that the quantity which can be collected from the roof surface of any town in this country will scarcely amount to 2 gallons per inhabitant daily, assuming that the average rainfall is 20 inches, and that house accommodation gives a roof area of 60 square feet for each individual. The following table, by W. Sowerby Wallis, F.M.S., shows the daily yield of water from a roof with varying rainfalls.

Area of House, 10 feet by 20 feet, or 200 square feet.					
Mean Rainfall.	Loss from Evaporation.	Requisite capacity of Tank.	Mean daily yield of Water.	Mean daily yield of Water in wettest year.	Mean daily yield of Water in driest year.
inches.	per cent.	cubic feet.	gallons.	gallons.	gallons.
20	25	100	4·3	6·7	3·2
25	20	135	5·7	7·5	3·9
30	20	145	6·8	9·4	4·5
35	20	155	7·9	11·0	5·0
40	15	165	9·7	13·1	7·2
45	15	170	10·9	14·2	8·6

For any other size of roof or amount of rainfall, the numbers will be proportional.

If, instead of the roof-surface, a cemented piece of ground is the receiving area, the superficial area in square yards, multiplied by the rainfall in inches, and this again by 4·673, will give the total number of gallons, because one inch of rainfall delivers 4·673 gallons on every square yard.

If lines be drawn through the sources of the tributaries of rivers marked on a map, they will be found to form the boundaries of certain areas which are called the catchment basins of the various rivers—that is, the areas which receive the rainfall supplying their waters. In compact formations, where most of the rain runs off the surface, the ridge lines bounding these basins usually pass along the most elevated regions, but in porous formations their course will depend on the configuration of the retentive substratum.

The amount of rainfall which penetrates beneath the surface varies according to the density and configuration of the ground, and also depends on whatever influences the rate of evaporation. Thus in loose sandy or gravelly districts as much as 90 to 96 per cent sinks into the soil; in chalk districts, 42; in limestone, 20; while in districts of retentive impermeable clay the percentage is

very small. Dr. Dalton, in his experiments on the new red sandstone soil of Manchester, found that 25 per cent of the whole rainfall penetrated to the depth of 3 feet; and Mr. Prestwich gave the amount of infiltration of the principal water-bearing strata surrounding London as varying from 48 to 60 per cent.

Other things being equal, the amount of infiltration will be far less in an undulating hilly district than in open level plains. It is obvious also that it must vary very considerably with the season of the year. Thus, according to the experiments of Mr. Dickinson, made in the gravelly loam which covers the chalk in the valleys around Watford, it was 70 per cent in the first three months of the year; in the summer months it was only 2; while in November and December nearly the whole of the rainfall penetrated beneath the surface.

2. *Water from Wells, Springs, Rivers, and Lakes.*— The quality and composition of the water derived from these sources depend on the nature of the soil and geological strata through which it has passed, or on the character of its surface-bed or channel. The rain, already charged with carbonic acid in its passage through the lower regions of the atmosphere, becomes still more largely impregnated with this gas when it sinks beneath the surface. In some rich soils the amount present in the air contained within their interstices, according to Boussingault, is 250 times greater than the ordinary atmospheric ratio. Aided by the action of the carbonic acid which it has thus absorbed, the rain water dissolves and decomposes various chemical compounds which it meets with in its underground progress, and often becomes so highly charged with them as to become unfit for ordinary use, as in the case of mineral waters.

(1.) Surface or shallow-well waters, though sometimes comparatively pure, frequently contain a large

amount of organic matter. In mossy moorland districts, for example, or in rich vegetable soils, the water may contain from 12 to 30 grains of vegetable matter per gallon, which imparts to it a yellowish or brownish tint; while in marshy districts the amount of organic matter varies from 10 to 100 grains. The saline constituents depend very much upon the geological character of the stratum in or upon which the well is sunk, but in inhabited places these are often masked by the products of excremental pollution. Shallow-well waters are drawn from wells not more than 50 feet deep, and seldom exceeding half that depth. Surface waters from cultivated land are always more or less contaminated with manurial impurities, and should therefore be efficiently filtered before being used.

(2.) The water from deep wells and springs varies according to the geological strata through which it passes. Thus alluvial waters are more or less impure, containing a large amount of salts (20 to 120 grains per gallon), and often much organic matter; while the chalk waters are clear, wholesome, and sparkling, holding in solution a considerable amount of calcium carbonate besides other salts, and being largely impregnated with carbonic acid. Also wholesome and agreeable to the taste, but not so suitable for cooking purposes, is the water from the limestone and magnesian limestone strata. It contains more calcium and magnesium sulphate than the chalk water, and consequently does not become so soft on boiling. Waters from the granitic, metamorphic, trap-rock, and clay-slate formations are generally very pure, and contain but small quantities of solids, consisting chiefly of sodium carbonate and chloride, with a little lime and magnesia. Waters from the millstone grit and hard oolite are also very pure. The saline constituents are by no means excessive, and are chiefly in the form of calcium

and magnesium sulphate and carbonate, with traces of iron. Soft sand-rock waters, loose sand and gravel waters, and waters from the lias clays vary very much in quality and composition, some of them being very pure, as the Farnham waters, and others containing large amounts of mineral and organic matters.

(3.) River water is in most cases softer than spring or well water. It contains a smaller amount of mineral salts, but is often largely impregnated with organic matter on account of the vegetable *débris* and animal excreta which find their way into it. Its constant movement, however, facilitates the oxidation of organic impurities, and this purifying process is aided to some extent by the presence of fresh-water plants.

(4.) Lake water, especially in mountainous districts composed of the older rock formations, is generally very soft, containing little mineral matter; but as it is essentially a stagnant water, and as all lakes receive the washings of the districts in which they are situated, the amount of organic nitrogenous matter is sometimes very considerable. Any excess, however, of peaty matter in solution may be materially lessened by filtering through sand.

As regards the qualities of potable waters founded upon their respective sources, the following classifications are given by the Rivers Pollution Commissioners in their Sixth Report:—

I. In respect of wholesomeness, palatability, and general fitness for drinking and cooking:—

Wholesome.	1. Spring water.	Very palatable.
	2. Deep-well water.	
	3. Upland surface water.	Moderately palatable.
Suspicious.	4. Stored rain water.	
	5. Surface water from cultivated land.	Palatable.
Dangerous.	6. River water to which sewage gains access.	
	7. Shallow-well water.	

II. According to softness :—

1. Rain water.
2. Upland surface water.
3. Surface water from cultivated land.
4. River water.
5 Spring water.
6. Deep-well water.
7. Shallow-well water.

III. In respect of the influence of geological formation in rendering water sparkling, colourless, palatable, and wholesome, by percolation, the following water-bearing strata are given as the most efficient :—

1 Chalk.
2. Oolite.
3. Greensand.
4. Hastings sand
5. New red and conglomerate sandstone.

Section II.—Quantity necessary for Health and other Purposes.

A healthy adult requires daily from 70 to 100 oz. of water for the processes of nutrition, about one-third of which is contained in articles of diet, the other two-thirds being supplied in the form of liquids. The amount for cooking has been estimated at from half a gallon to a gallon daily for each person, while the quantity deemed necessary for personal cleanliness and for washing purposes will necessarily vary very much according to the habits of the individual.

Dr. Parkes has given the following quantities used by a man in the middle class :—

	Gallons daily.
Cooking	·75
Fluids as drink	·33
Ablution, including a daily sponge-bath .	5
Share of utensil and house washing . .	3
Share of clothes washing	3
	12·08

The soldier is allowed about 15 gallons daily, no extra allowance being given for the women and children in a regiment. In the poorer districts of the city of London, Dr. Letheby found that the amount used was 5 gallons per individual daily, and in model lodging-houses, according to Mr. Muir, 7 gallons. In the cottages of the poor in country districts where water is scarce, the amount in many instances does not exceed 3 gallons, but then the inhabitants are not cleanly. A shower-bath daily will require 3 to 4 gallons, while a plunge-bath will take from 40 to 60 gallons. Where water-closets are used, an additional allowance of from 4 to 6 gallons must be provided. Latrines require a less amount.

In gross amounts Professor Rankine has given an estimate of 10 gallons daily per individual for domestic purposes, 10 for municipal purposes, and 10 more for trade purposes in manufacturing towns, and this amount, large though it seems, is actually supplied to many towns at the present day. Glasgow, for example, receives 50 gallons daily per head of population; Edinburgh and Southampton 35; Paris 31; and Liverpool 30. The different London water companies supply from 21 to 34 gallons—the mean average being 28; while the manufacturing towns in Lancashire and Yorkshire, according to Mr. Bateman, received from 16 to 21 gallons. In Norwich the average supply is only 12 gallons, and in Derby 14. In Warwick, by careful inspection as regards waste, it has been reduced from 22 to 15 gallons per

head daily, and Warwick is entirely a water-closet town. Mr. Rawlinson's minimum estimate for manufacturing towns is 20 gallons per head daily, and if care be taken to prevent needless waste this amount will be more than sufficient. There is no doubt that a large proportion of the waste is connected with water-closets, and especially those which are directly flushed from the mains by means of stool-taps, which should everywhere be abolished.

In apportioning the daily allowance for all purposes, Dr. Parkes has given the following estimate :—

	Gallons per head of population.
Domestic supply	12
General baths	4
Water-closets	6
Unavoidable waste	3
Total house supply	25
Municipal purposes	5
Trade purposes	5
Total	35

No doubt this estimate may be regarded as somewhat excessive, especially in the items of domestic and water-closet supply, but it has been based on the principle that a liberal allowance is not only necessary for thorough cleanliness, but that it is also required for an efficient clearage of sewers. There can be no question, however, that the amount of water habitually wasted in many towns is enormous, reaching in all probability to at least one-third of the supply, and this, when the water has to be pumped into the town, or when the town sewage has to be pumped or chemically treated in any way at the outfall, increases the rates to a very considerable extent. While part of this waste is due to underground leakage from pipes and mains, by far the larger portion of it is due to imperfect household fittings, and to carelessness in

leaving stool-cocks and bib-cocks open in connection with water-closets whose flush pipes communicate directly with the mains. All closets should be provided with cisterns of the waste-preventing class, but of sufficient capacity to flush the closet-pan when used.

For hospitals the daily amount per patient may be estimated at about 30 gallons. In prisons and work-houses the quantity will vary according to the bathing arrangements, and whether water-closets are used. In the Convict Prison, Portsmouth, where water-closets and water-latrines are both in use, and where each prisoner is allowed a general bath once a week, I found that the amount averaged about 11 gallons per convict daily.

Section III.—Modes of Supply.

This part of the subject has reference to wells, borings, the collection and storage of water, and to waterworks generally.

1. *Wells and Borings.*—In small urban and rural districts surface wells, whether as ordinary pump wells, draw wells, or shallow dip wells, constitute the usual source of supply, and though they may naturally yield a wholesome water, the surrounding soil often becomes so saturated with impurities that it is next to impossible to prevent their pollution. In crowded localities, therefore, they should always be regarded with suspicion, and, as far as possible, their use should be discontinued. Deep wells, on the other hand, are not open to this objection, because they are generally sunk through an impervious stratum, which prevents the infiltration of any surface impurities, and at the same time serves to keep down the water in the porous strata beneath. The quality of the water from these wells, as has already been shown, will depend on the nature of the geological formation of the district. It

is also apparent that, in accordance with a well-known physical law, it is only necessary to bore through the impervious stratum, and reach the water-bearing bed, for the water to rise to the surface, or to within a short distance of it, so as to be collected in a well of ordinary dimensions. Indeed, in certain low-lying districts, where a boring is made at a point considerably below the level of the line of infiltration into the water-bearing stratum, the water rises above the surface and overflows. Such overflowing wells, or artesian wells as they are called, were once common in the valley of the Thames, and are still to be met with in the flat lands of Essex and on the coast of Lincolnshire. Ordinary borings differ from artesian wells in not piercing through a retentive stratum in order to reach the water-supply. They are very common in the chalk and new red sandstone districts, and are made to increase the yield of the wells. Practically, it is found that one boring adds to the supply of a well nearly as much as several. Thus in the Bootle well at Liverpool, with 16 bore-holes, some of which were 600 feet deep, Mr. Stephenson found that when all were plugged up but one, the yield was 921,192 gallons per day, and when all were open it was only increased by 112,792 gallons.

Deep wells are now being abandoned for the supply of large towns, because they are found to be insufficient for the wants of a rapidly-increasing population, and obviously cannot be multiplied within a given district beyond certain limits, because every single well drains a surrounding area of some considerable extent. For large isolated buildings, however, such as lunatic asylums, workhouses, and prisons, they usually supply the whole of the water required; and in selecting a site in the country for any such building, the possibility of obtaining the requisite water-supply, and the cost at which it can be procured, are points of the first importance.

Generally speaking, the chance of obtaining a good supply will depend upon the nature of the underlying strata, and upon the level of the proposed site. Wells sunk in superficial sand or gravel beds, though yielding a good supply at ordinary times, are very liable to have their yield very much lessened in seasons of drought, unless they are situated at points considerably below the level of the surrounding country, and the same remark applies to surface wells in the chalk districts. On the other hand, deep wells or borings in the new red sandstone, and oolite or chalk formations, usually yield a large and constant supply, because these permeable rocks are so saturated with water that they may be regarded as vast subterranean reservoirs. The deepest artesian wells in the world are those at Grenelle in Paris and Kissengen in Bavaria, the former being 1800 and the latter 1878 feet in depth.

The Commissioners, in the report already alluded to, strongly urge "that preference should always be given to spring and deep-well water for purely domestic purposes, over even upland surface water, not only on account of the much greater intrinsic chemical purity and palatability of these waters, but also because their physical qualities render them peculiarly valuable for domestic supply. They are almost invariably clear, colourless, transparent, and brilliant, qualities which add greatly to their acceptability as beverages; whilst their uniformity of temperature throughout the year renders them cool and refreshing in summer, and prevents them from freezing readily in winter. Such waters are of inestimable value to communities, and their conservation and utilisation are worthy of the greatest efforts of those who have the public health under their charge."

The following are some of the towns which are supplied by deep wells:—Canterbury, Cambridge, Bury St.

Edmunds, and Deal from the chalk formation; Birkenhead, Coventry, Leamington, and Southport from the new red sandstone; and Bedford and Scarborough from the oolite.

For a small or temporary supply the American tube well (Norton's patent) has been found to be very useful. It consists of a narrow iron tube driven into the ground in lengths, the lower part being pointed and perforated at its end, and is fitted with a single or double action pump according to the depth. The water enters the tube through the perforations, and, if the bed is sandy, has to be filtered for some time, until, by gradual removal of the sand, a well is formed around the lower end, and the water is obtained without sediment. This pump is especially adapted for country districts, and it possesses the further advantage of helping to keep out surface impurities. Tube wells of a similar description are manufactured by Le Grand and Sutcliffe, Bunhill Row, London, E.C.

In order to ascertain the yield of surface wells, the water must be pumped out, and the time noted which is required for refilling. The yield of small springs can be readily measured by receiving the water into a vessel of known dimensions, such as a cask, and also noting the time which it takes to fill.

2. *Waterworks.*—In addition to deep wells, waterworks on an extensive scale obtain their supply from lakes, streams, rivers, or gathering-grounds. If from a lake of sufficient elevation above the level of the town to be supplied, the water may be distributed throughout the town in conduits and pipes by the force of gravity. When the source of supply is a stream or small river, storage works are necessary; but when the river is large, a constant supply can be obtained at all times, independently of storage. In this case the works required usually

comprise—a weir or dam for maintaining part of the river at a nearly constant level; two or more settling-ponds, into which the water is conducted; filtering apparatus, and pumping engines.

When it is required to ascertain the yield of any small stream, it is usual to employ a weir-gauge to dam up the water into a pond behind, and allow it to flow through a sluice or over a sill of known dimensions. In the case of an average-sized stream, a rough approximation of the yield may be obtained by taking the breadth and depth at several distances in a short section of the channel which is tolerably uniform, and thus ascertaining the average sectional area. The surface velocity may then be taken by noting the time occupied in floating a light object over the selected distance, and as four-fifths of the surface-velocity are about equal to the actual velocity, the yield in cubic feet or gallons per second can be easily calculated.

When the water-supply of a town is collected from small streams or gathering-grounds, the rainfall of the catchment basin and its available amount are items which ought to be carefully inquired into. The ratio of the available to the total rainfall, as already shown, is influenced by the nature of the soil, the steepness or flatness of the ground, the rapidity of the rainfall, and other circumstances. Professor Rankine has given the following examples:—

Ground.	Available Rainfall divided by Total Rainfall.
Steep surfaces of granite, gneiss, and slate .	nearly 1
Moorland hilly pastures	from ·8 to ·6
Flat cultivated country	from ·5 to ·4
Chalk	0

The average annual rainfall in different parts of this country varies from 22 to 140 inches, the least recorded

depth being 15 inches. It is greater in mountainous than in flat districts, and on the leeward side of a mountain ridge than it is on the side facing the prevailing winds. As regards water-supply, the most important data are the least annual rainfall and the longest period of drought.

In selecting drainage areas, it must be borne in mind that the nearer the actual rainfall water is collected the freer it will be from impurities, and that purity of water and fertility of soil are not to be expected together. Water collected from a peaty soil will contain large quantities of vegetable matter, while that from a soil well cultivated will be tainted with animal impurities. The purest water, therefore, which can be collected from drainage areas is found in the barren moorland districts of the primary geological formations, or of the sandstone rocks.

The channels of the gathering-ground may either be the natural watercourses of the district, or these may be supplemented by adits, closed drains, or open ditches. The latter, however, are objectionable because they form receptacles for vegetable matter, and as the current in them must be necessarily slow, there is considerable loss by evaporation. The position, extent, and dimensions of the adits leading to the reservoir will depend upon the configuration of the district. The reservoir itself is generally a natural hollow, situated in the valley-line of the catchment basin, and of sufficient elevation to procure a fall, so that the water can be distributed without mechanical means being required to raise it. In this country the storage-room should be large enough to contain a four or six months' supply; and the site which can supply the requisite storage-room with the least embankment, the least amount of puddle, and the least area laid under water is to be preferred.

Upon the strength and stability of the embankment everything depends. It is made water-tight by a core of clay puddle, the inner slope being protected from the action of the water by a pitching of dressed stones, and the outer from the effects of the weather by a covering of grass sods. The puddle-core generally amounts to a tenth of the whole embankment. The height of the embankment varies from 3 to 10 feet above the highest water-level, the top being covered with broken stones. No trees or shrubs are allowed to grow upon it, and the greatest care is taken in its construction to prevent animals, such as water-rats, burrowing into it.

Every impounding reservoir, as it is called, is provided with an overflow weir to permit the discharge of the flood supply from the drainage area, and this is often supplemented by a channel termed the *bye-wash*, which is used to divert the streams supplying the reservoir, so as to prevent fouling of the store-water. The flood-water carried off in this way flows into the natural watercourse.

In order to remove the sediment which collects in the bottom of the reservoir, there is always a cleansing pipe as well as a discharge-pipe, the former being on a level with the lowest point in the reservoir, and discharging into the natural watercourse below the embankment. Both are carried through a culvert in the embankment, which is built of stone or brick, and founded on the solid rock. The aqueduct or discharge-pipe bends upwards in the reservoir, and has a series of inlets, the lowest at the lowest working level, and the whole of them guarded against the entrance of small stones, pieces of wood, or other bodies, which would interfere with the action of the valves. The sluices which are required for both pipes are situated in the reservoir, and are worked from the sluice-tower.

The aqueduct is that portion of the conduit leading from the reservoir to the distributing conduits. It may be open or close throughout, or partly close and partly open. If close, it generally consists of a train of cast-iron pipes securely jointed, bedded on a firm foundation, and covered to a depth of at least 2 or 3 feet, to preserve them from frost. Sluice stop-cocks are provided in the valleys, for the purpose of scouring out any stones or sediment, and, at intervals not exceeding half a mile, to permit of repairs. Valve-cocks are supplied at all the principal summits, to allow the escape of air. When the aqueduct is partly close and partly open, or if, when close, it cannot withstand the whole pressure when the demand ceases, either a system of weirs is required to discharge the surplus water, or a second store-reservoir is provided, resembling in general plan and construction the impounding reservoir.

The distributing conduits also consist of cast-iron pipes, and are coated, like the aqueduct pipes, with pitch, or Dr. Angus Smith's varnish, to preserve them from corrosion. The same details with regard to sluice-cocks and stop-cocks are observed in the different bends of the tracks, with this addition, that the dead ends or terminations of the branch and main conduits are supplied with scouring valves, through which stones and sediment can be washed. In wide streets, or in streets with much traffic, there is generally a service-pipe for each side, in order that the house-pipes may be as short as possible, and may be accessible without disturbing the traffic. The house service-pipes are usually made of lead, and though they are liable to be acted upon by some waters, the readiness with which they can be adapted to all the bends and curves rendered necessary in carrying the piping to different floors of houses, gives them a preference to all other kinds of metal pipes. The waters which act most

on lead are the most highly oxygenated, and those which contain organic matter; those which act least on it contain carbonic acid, calcium carbonate, and calcium phosphate. Polluted shallow-well waters are especially dangerous in this respect, because they act on it violently and continuously, and hence leaden pump-pipes should never be used. Various means have been proposed to protect the lead from corrosion, such as coating with bituminous pitch or with coal tar; but when the quality of the water renders lead pipes objectionable, cast and wrought iron pipes make the best substitutes, or composite cylinder pipes. These pipes consist of a separate tube of pure block-tin encased in lead, and the union of the two is so perfect that no amount of torsion will separate them.

As the greatest hourly demand for water is about double the average hourly demand, the main conduits supplying a town must have double the discharging capacity which would be required if the hourly demand were uniform. The additional expense in piping which would be thus entailed is sometimes so great that distributing basins or town-reservoirs are constructed to supply certain districts. To meet all emergencies, they are made large enough to contain at least a day's supply, and they must also have a site of sufficient elevation to ensure distribution by hydrostatic pressure. Every such reservoir should be roofed in and ventilated, to protect the water from frost and heat, and from becoming tainted with aerial impurities.

The water thus distributed to the various houses in a district is supplied either on the intermittent or constant system. The intermittent system necessitates storage in house cisterns, and is attended by so many disadvantages that the constant system should always be adopted wherever it can be carried out. The use of

cisterns, except on a small scale, for water-closets and boilers is open to the great objection of the risk of contamination of the water, for not only are the cisterns liable to become fouled if not sufficiently protected against the entrance of aerial impurities, but the water is apt to become tainted with sewer-gases. Moreover, in poorer districts, the cisterns are often of a very inferior description, are badly situated, and are seldom inspected or cleaned out. To meet this objection it has been proposed to have one large tank for the supply of a group of houses,—the tank to be under the immediate inspection of the waterwork officials, and to be filled daily, and the householders to be supplied through small pipes constantly charged. It is further urged against the intermittent system that the distribution pipes, being alternately wet and dry, are liable to collect dust and the effluvia from sewers or drains. The objections to the constant system, on the other hand, are the great waste when the fittings are imperfect, and an insufficient delivery when the water-supply is not abundant. The diameters of the pipes for constant service should therefore be carefully adapted to their discharges and to the head of pressure; the drawing taps ought to be valve-cocks to open and shut with a screw; and the town should be efficiently provided with distributing basins, so that an extra flow of water in one district would not interfere with the requisite supply of other parts. With proper fittings, strict regulations, and efficient supervision, it is now clearly established that a constant supply requires a less amount of water than an uncontrolled intermittent supply, so that even on the score of economy the constant system is to be preferred.

In order to prevent undue waste, water-meters are sometimes applied to the service-pipe supplying a group of houses, and the landlord charged for the amount used;

but as this plan induces the landlord to enforce a too rigid economy, it is not to be commended. The best water-meters are capable of registering exactly all amounts exceeding a flow of one gallon per hour; but when the water contains a considerable amount of undissolved impurities, and is badly filtered, they very soon become clogged up and fail to register anything like the quantity of water which may pass through them.

The waste-preventer, or small cistern for the supply of water-closets, which has already been alluded to, should at least hold 2 gallons, and in order to secure a good flush the service-pipe should be at least $1\frac{1}{4}$ inch in diameter.

Another plan for effecting economy in the constant system proposes that a cistern, large enough to hold a twenty-four hours' supply, be provided for each house, and that the service-pipe shall be of a diameter to deliver the required quantity during that time, and nothing more. Every cistern supplied in this way would become gradually emptied during the day time, and would be refilled during the night; but the plan is open to the great objection attaching to the intermittent system, and does not sufficiently provide for emergencies.

Wherever cisterns are employed for potable water they should be so situated that they can be readily cleaned out when necessary. The best materials for their construction are slate-slabs well set in cement, or galvanised iron. Leaden cisterns, unless lined with a coating of pitch, tar, or other preservative substances, are objectionable. All cisterns should be covered in, and protected from heat and frost. No cistern which supplies water for domestic use should be used to directly supply a water-closet; a waste-preventing cistern should always intervene. The inlet to every cistern ought to have a cock, with a float to rise and stop the supply when the cistern is full; and when the supply is constant, the

overflow should be so arranged as to be seen if not immediately rectified. An overflow-pipe from a cistern should never lead directly into a soil-pipe, sewer, or drain, but should end above ground over a trapped and ventilated grating. If this were always attended to, no sewer-gases could find their way to the cistern through this channel.

In addition to the arrangements for domestic supply, outlets or hydrants with valve-cocks are provided on the service-pipes of all large towns, at regular intervals, in case of fire, and for supplying water to flush the gutters and water the streets.

In laying down water-pipes and mains it is of great importance that the separation between them and sewers, drains, or gas-pipes should be as wide as possible. Whether the water-supply be on the constant or intermittent system, the risk of suction of gases or fluids into leaky mains is imminent, though of course much less when the supply is constant. Unfortunately, however, this danger of contaminating public water-supplies has hitherto not been appreciated, and indeed in many towns it has been enhanced by arrangements for flushing sewers directly from the mains.—(See Mr. Simon's *Reports*, New Series, No. VII.)

Another danger to a public water-supply is the direct connection of water-mains with closet-pans. In Warwick and Rugby I found that nearly one-fourth of the closets were flushed directly from the main by means of stool-cocks, and on my recommendation the whole of them were disconnected. As a consequence of this precautionary measure, although the water-supply was made intermittent in Warwick during three months of last year owing to continued drought, the town continued entirely free from enteric fever, nor was there any excess of diarrhœa.

Section IV.—Purification of Water.

On an extensive scale the process of purification is carried on by means of filtration, the water being received into large filter-beds previous to its distribution. A filter-bed may be described as a tank or reservior several feet in depth, with paved bottom, on which are laid a series of open-jointed or perforated tubular drains leading into a central culvert. The drains are covered with a layer of gravel about 3 feet deep, over which is spread a layer of sand about 2 feet deep. The layer of gravel is coarse at the bottom, becoming gradually finer towards its upper surface, and the same relative gradation, as regards coarseness and fineness, is observed with regard to the sand. The water is delivered uniformly and slowly, and in order that the filtering process may not be carried on hurriedly, the pressure is always kept low, the depth of water being seldom above 2 feet, and in some cases only 1 foot. The speed of vertical descent should not be much above 6 inches per hour, nor should the rate of filtration much exceed 700 gallons per square yard of filter-bed in the 24 hours, although some water companies filter at a much more rapid rate than this. In large works there are always several filter-beds, to allow of some being cleansed while the others are in use. The sediment deposited on the surface of the sand requires to be scraped off at intervals, and at each cleansing operation about half an inch of sand is also removed. A fresh supply of sand is added when the depth of the layer is reduced to an extent which threatens to impair the efficiency of the filter. It appears that proper filtration, carried on according to this plan, removes suspended impurities, and a certain amount of dissolved mineral substances, but whether dissolved

organic matters are destroyed, or oxidised to any considerable extent, seems doubtful.

Small filters for domestic use may be placed in the cistern, in the course of the delivery-pipe, or they may be filled by hand. As filtering media various substances are used, such as animal or vegetable charcoal, a mixture of fine silica and charcoal, magnetic carbide of iron, sponges, wool, etc. The best filters are made either of animal charcoal or magnetic carbide of iron or spongy iron. They are capable of removing almost all the suspended matters, and at least 40 per cent of dissolved organic impurities, together with a considerable amount of salts, such as calcium carbonate and sodium chloride. Indeed, the experiments of Mr. Wanklyn with the silicated carbon-filter prove that, by repeated filtration, river water containing a considerable amount of free and albuminoid ammonia may be made as pure as deep spring water.

Of filtering media, animal charcoal, properly washed, is most generally used, but it should be frequently renewed. It exerts a chemical as well as mechanical action on organic impurities, and Dr. Frankland is so convinced of its value as a filtering agent that he recommends its employment on a large scale for the purification of town supplies, in spite of the cost which would be entailed. Professor Bischof has also discovered that spongy iron possesses remarkable purifying properties, which have been fully confirmed by the experiments of the Rivers Pollution Commissioners, and it may here be stated that the spongy iron filter received the medal of the Sanitary Institute a few years ago for its general excellence. Carferal is another substance which has lately been introduced, and is highly spoken of as a filtering medium. It resembles charcoal in appearance, and consists of a mixture of charcoal, iron, and clay.

Amongst other filters which have been commended

for their efficiency may be mentioned the cistern filter of the Water Purifying Company, London; Lipscombe's Self-Cleaning Charcoal Filter; the Patent Carbon Block Filter, manufactured by Atkins and Co., London; the Carbon Cistern Filter, planned by Mr. Finch of the Holborn Sanitary Works; and the various filters devised by Halliday and Co. of Manchester, and Doulton and Co. of London. All of these contain animal charcoal as the filtering medium, and can be applied to any kind of house cistern. The filtering block of the Silicated Carbon Company consists of 75 per cent of charcoal and 22 of silica, with a little iron oxide and alumina. It is cemented into a vessel which it divides into two chambers, the one containing the filtered and the other the unfiltered water. This filter is found to work very efficiently, and with a little care retains its properties for a long time. The filtering material of the Magnetic Carbide Filter is prepared by heating hæmatite with sawdust, and has all along been highly commended. The Patent Moulded Carbon Filter makes an elegant article for the sideboard. It consists of two glass vessels, the upper containing the filter-block, and the lower, which can be used as a water bottle, the filtered water. Tap-filters, suited for a high or low pressure, can be fitted to the pipes themselves. They contain charcoal or silicated carbon, and would seem to act very well. Mr. Bailey Denton's "Self-Supplying Aerated Filter" is placed beneath the house cistern, and by a simple arrangement of valve-cocks as much water is supplied to the cistern as is removed from the filter every time water is drawn off. Amongst other domestic filters may be mentioned Dr. Bond's Patent Floating Feed Filter and Floating Syphon Filter, Dr. Bernay's Manganous Carbon Filter, and M. Maignen's "Filtre Rapide," in which asbestos cloth and a substance called carbocalcis are employed as the filtering media.

A charcoal filter has been introduced by Lieut.-Col. Crease, of the Royal Marine Artillery, which, for simplicity of construction, adaptability to different kinds of water and rates of supply, and for efficiency, deserves special notice. It is now largely used in the navy, and is specially suited for large buildings, such as asylums, workhouses, etc. The tank is made of iron, lined with cement, and the whole of the apparatus can be readily unscrewed, taken to pieces, and cleaned out when necessary, the joints being made water-tight by gutta-percha bands. Pocket Syphon Filters are made of hollow blocks of charcoal, with a tube passing into the cavity, into which the water filters through the charcoal.

All filters after a time become clogged up, and have therefore to be taken to pieces and throughly cleansed; or, if this cannot be easily done, they may be purified by passing through them a solution of potassium permanganate or Condy's fluid, with the addition of a few drops of strong sulphuric acid, and afterwards two or three gallons of pure or distilled waters acidulated with hydrochloric acid. The charcoal in a filter may also be purified by exposing it for some time to the sun and air, or by heating it in an oven or furnace. In the spongy iron filter the filtering medium has to be renewed from time to time.

The purification of water without filtration is not carried on in this country on the large scale except by Dr. Clark's process. This consists in adding a certain amount of lime water to a water which contains calcium carbonate rendered soluble by the presence of carbonic acid. Spring waters in the chalk districts are all more or less "hard," and many of them contain such a large amount of calcium carbonate in solution as to be unfit for washing purposes. Such a water, when it is to be rendered "soft" by Clark's process, is let into a tank or

reservoir, where it is mixed with a proper proportion of lime water and allowed to settle, the whole of the calcium being precipitated as calcium carbonate. A perfectly clear and wholesome water is thus obtained, well suited for domestic purposes. Calcium carbonate may also be removed by boiling, in which case it is deposited as an incrustation on the inner surface of the kettle or boiler. What is known as the "Porter-Clark Process" is a modification of Clark's process, which, at the same time, provides for very efficient filtration.

Aluminous salts have long been used in Eastern countries to purify water, and are found to be very efficacious in removing suspended matters, whether organic or mineral. Suspicious waters should always be boiled before being used.

Among other purifying agents may be mentioned distillation, the exposure of water in minute divided currents to the air, the immersion of pieces of charcoal or of iron wire, and the effects of plants and fish. In store reservoirs, the presence of a moderate quantity of living plants exerts a decidedly purifying influence, while the destruction of fish has been followed by an excessive multiplication of the small crustacean animals on which the fish had lived, thereby rendering the water nauseous and impure. The remedy was found in re-stocking the reservoir with fish.—(*Rankine.*)

Section V.—Sources of Pollution.

Although reference has already been made in the preceding remarks to various ways in which drinking water becomes polluted, it will be expedient to consider this important part of the subject somewhat more fully in detail; and first with regard to the water-supply of rural and small urban districts.

Estimating the town population of Great Britain at about fifteen millions, the Rivers Pollution Commissioners observe that "the remaining twelve millions of country population derive their water almost exclusively from shallow wells, and these are, so far as our experience extends, almost always horribly polluted by sewage, and by animal matters of the most disgusting origin. The common practice in villages, and even in many small towns, is to dispose of the sewage and to provide for the water-supply of each cottage, or pair of cottages, upon the premises. In the little yard or garden attached to each tenement, or pair of tenements, two holes are dug in the porous soil; into one of these, usually the shallower of the two, all the filthy liquids of the house are discharged; from the other, which is sunk below the water line of the porous stratum, the water for drinking and other domestic uses is pumped. These two holes are not unfrequently within twelve feet of each other, and sometimes even closer. The contents of the filth hole or cesspool gradually soak away through the surrounding soil, and mingle with the water below. As the contents of the water hole or well are pumped out, they are immediately replenished from the surrounding disgusting mixture, and it is not therefore very surprising to be assured that such a well does not become dry even in summer. Unfortunately, excrementitious liquids, especially after they have soaked through a few feet of porous soil, do not impair the palatability of the water; and this polluted liquid is consumed from year to year without a suspicion of its character, until the cesspool and well receive infected sewage, and then an outbreak of epidemic disease compels attention to the polluted water. Indeed, our acquaintance with a very large proportion of this class of potable waters has been made in consequence of the occurrence of severe outbreaks of

typhoid fever amongst the persons using them."—(See *Sixth Report.*)

Although it can scarcely be said that this description applies to rural districts generally, there can be no doubt that it still represents the condition of the water-supply of a vast number of villages and scattered country houses. Cesspools, cesspits, or drains, in close proximity to wells, are a fruitful source of mischief; and so also are midden-heaps or deep ashpits connected with privies, and the huge manure-heaps which are allowed to accumulate in farmyards. All such collections of liquid or solid filth should be regarded as dangerous nuisances, and should either be done away with altogether, or such adequate precautions taken as will obviate the risk of soakage into the well. The substitution of a dry system of conservancy and the use of pails or boxes for the cesspool, common privy, and cesspit, together with better scavenging, would lessen to a very large extent the dangers of well-pollution in country districts; but in crowded localities the soil becomes so saturated with filth of all kinds that surface wells are never safe. All pump wells should be clay-puddled to a depth of eight or ten feet, to keep out surface impurities; and instead of draw wells or shallow open dip wells, which are especially liable to pollution, either proper pump wells should be provided, or, where the nature of the subsoil is suitable, tube wells would be found to possess many advantages. Surface wells near graveyards are very often found to be polluted.

But even when there is no drain or cesspool near, a well frequently becomes polluted because it is never cleaned out, and for my own part I regard this periodic cleansing of wells so necessary that I think every pump well should be provided with a manhole and be cleaned out at stated times. In towns or large villages provided

with a public water-supply, the closing of all surface wells, whether public or private, should be rendered compulsory; for, with drains ramifying in every direction, it may be taken for granted that they are either polluted, or are at all events constantly liable to pollution.

With regard to public supplies, it may be stated, generally, that water may become polluted either at its source, in the course of distribution, or through defects connected with its storage. Any supply which is taken from a river polluted by the sewage of towns up-stream must be carefully filtered, and even then it can only be regarded as a suspicious water. Deep wells or springs, on the other hand, may become polluted by the entrance of surface impurities, or by the access of polluted water through open fissures in the rock. But perhaps the most frequent and insidious sources of pollution to which public supplies are exposed are those dependent upon the arrangements for distribution and storage. It has already been pointed out that, with an intermittent supply, the mains must necessarily become full of air when the water is turned off, and if at all leaky, as they very often are, they may become charged with liquid as well as aerial impurities. Moreover, when water-closets are served direct from the mains by mere taps or stopcocks, there is always the danger of liquid filth being sucked into them whenever a closet-pipe becomes choked up, and the pan becomes full. The following experiment will illustrate how readily such pollution may occur :— In the report on Croydon, already referred to, Dr. Buchanan states that he had a common house tap connected with a pan containing solution of burnt sugar sufficient to colour some thousand gallons of water, and that in the ordinary night-intermission of supply, the whole of this was straightway sucked into the pipes, and, except from one neighbour, was no more heard of. He also adds that

there is an instance on record of bloody water coming from the main tap of a house situated next to a slaughter-house. Then, too, connected with this system of intermittent supply, there are all the risks of contamination attaching to cisternage, or storage in pails, butts, or other receptacles. If the same cistern is used to supply the house and the water-closet as well, sewer-gases from the closet have access to the surface of the water in the cistern; or should the overflow pipe from the house cistern discharge direct into a sewer or drain, there is of course the same danger. Apart also from the risk of lead-pollution from leaden cisterns, the water stored in a cistern may eventually become unfit for use, because the cistern is seldom or never cleaned out.

But even with a constant supply there appear to be certain dangers depending upon possible in-currents from leaky mains, especially when these are in juxtaposition to sewers or drains which have hitherto escaped the notice of engineers. The physical conditions under which such in-currents may take place have been investigated to a certain extent by Dr. Buchanan, and I quote his results here, in order that others may be induced to make experiments in the same direction. In a note appended to the Croydon report he gives the following summary of results:—"I find (1) the lateral in-current is freely produced when the water-pipe is descending, and when the pipe beyond the hole is unobstructed; (2) if the force of water-flow in a descending pipe be moderate, a moderate degree of obstruction beyond the hole does not prevent the in-current; (3) in horizontal pipes of uniform calibre, when the flow is strong, or the pipe beyond the hole is long, or when the end of the pipe is at all turned upwards, the in-current does not take place, but (4) momentary interference with flow *a tergo*, or momentary reduction of obstruction *a fronte*, allows of

a momentary in-current through the hole; (5) in-current through a lateral hole takes place with incomparably greater ease when the hole is made at a point of constriction of the water-pipe."

It has further to be observed that water mains, if not sufficiently protected against corrosion, may render the water turbid, owing to rusting of the iron; that the tow or gaskin employed to caulk joints may taint the water for a long period if the main is several miles in length; and that leaden pipes, especially when first laid down, may become a source of danger if the water is soft.

With regard to the general effects of drinking impure water, and particular outbreaks of disease depending upon ascertained sources of pollution, see Chapter VIII.

CHAPTER VII.

WATER ANALYSIS

Section I.—Collection of Samples.

In collecting water for analytical purposes, and particularly when it is intended to submit samples to a quantitative analysis, the following directions should be observed :—An ordinary glass-stoppered Winchester quart bottle will answer very well for the conveyance of the water. It should be cleaned out with strong sulphuric acid, then rinsed with ordinary good water until the rinsings are no longer acid, and finally washed out with some of the water to be examined. The bottle should be filled almost up to the neck, stoppered, and the stopper covered over with a piece of clean calico, wash leather, or gutta-percha tissue, tied, and sealed. No luting should be used except sealing-wax, and even that should be dispensed with if possible. If the water contains organic matter, it should be examined at least within forty-eight hours after being collected.

In collecting pond or lake water the bottle should be plunged into the water as far as possible from the bank, with the mouth well under the surface, so as to avoid the scum, care being taken, at the same time, that the mud at the bottom is not disturbed. If the sample is taken from a town supply, it should, if possible, be collected direct from the mains, or from the water-jets at the cab-

stands or public fountains, in which case the water should be allowed to flow for some time previous to filling the bottle. If taken from a house-service tap, the water should also be allowed to flow for some time before collecting. With regard to river water, it is recommended to select the middle of the stream, to avoid the outlets of sewers and feeders, and to note whether there has been previously a heavy fall of rain or a long drought. When a sample is required from the source of a spring, it is sometimes necessary to dig a small excavation and allow all sediment to subside before the sample is taken. Well-water should of course be drawn direct from the well.

Different methods of examination require different quantities; for Mr. Wanklyn's method one Winchester quart will be quite sufficient, but for a complete investigation some analysts require about a gallon. If a Winchester quart cannot readily be procured, a clear glass wine bottle will answer very well, but care must be taken to have it thoroughly clean, and the cork should be clean and new, and fit well.

The medical officer of health will find it very convenient to have a basket containing two or more clear glass-stoppered bottles placed under the charge of the sanitary inspector of the district. The basket should be provided with a padlock fitted with two keys, one of which should be in the possession of the medical officer of health and the other retained by the inspector. Before forwarding the bottles, the inspector should affix a label to each, containing the date and a distinctive number, or certain particulars with regard to the source of the water and why it is suspected. For ordinary analysis pint stoppered bottles will be found to be large enough, because, should a greater quantity be required at any time, two bottles can be used instead of one.

Section II.—Physical Examination.

A portion of the sample collected should be poured, after shaking the bottle, into a good-sized clear glass flask. If the flask is then held in front of a dark-coloured surface, with a good light falling on the side or from above, any suspended impurities will become visible, but care should be taken to discriminate between them and air-bubbles.

Colour and turbidity are best ascertained by pouring the water into a tall vessel of colourless glass, and placing it upon a porcelain slab or piece of white paper. Another glass of the same dimensions, filled with distilled water, should be placed by its side for comparison. Both samples are then looked through from above, and the difference between them noted. If organic matter is present, the water has usually a tinge of yellow, green, or blue, but mineral substances may give similar indications. Clay, peat, and other harmless contaminations impart a brownish tint. If the turbidity is considerable, or if the water is very dark in colour, it may be pronounced unfit for use, although filtration may render it perfectly wholesome.

To observe the smell of the water, a portion of it should be poured into a wide-mouthed flask, making it about one-third full, and then shaking it well. If the smell is unpleasant, the water is unfit to drink. Should no smell be detected, the flask should be heated, and the water again shaken, and if there is still no smell a little caustic potash should be added to the warm water. Any unpleasant odour which may now be given off indicates with tolerable certainty that the water contains organic impurities in considerable quantity. The occurrence of a precipitate on the addition of the caustic potash will at the same time indicate hardness.

With regard to taste, it is sufficient to say that a badly-tasting water should be condemned for drinking purposes. Many waters, however, which are largely impregnated with dissolved animal impurities may be quite palatable.

Altogether, the physical examination of water is of a negative character; and although it may impart some useful information, it cannot be relied upon in arriving at a sound conclusion as regards the good or bad qualities of any given sample.

Section III.—Microscopical Examination.

In order to collect the sediment the water should be poured into a large depositing-glass, and allowed to stand for 12 or 24 hours. Particles of sand are recognised by their angular shapes, and by their not being affected by acids. Particles of clay and marl are amorphous, and are also unaffected by acids. Particles of chalk are amorphous, and are readily dissolved by acids. Dead vegetable matter, such as woody fibre and portions of leaves, and living vegetable matter, consisting of confervoid growths, may all be detected in water which cannot be pronounced unwholesome. So also may *diatomaceæ*, *infusoria*, and *entomostraca*. Microscopical examination, therefore, is only valuable for practical purposes, in so far as it indicates the various components of the suspended matters; it gives no direct information concerning the presence of dissolved organic impurities. There is no doubt, however, that it presents a wide and interesting field for research, and in this respect the writings of Drs. Burdon Sanderson, Cohn, and Macdonald of Netley are extremely valuable. Reference should also be made to Koch's gelatine process, as recently explained by Dr. Angus Smith, which appears to be full of promise, and to indicate a new departure in water-

analysis.—(See Second Report to Local Government Board by Dr. Angus Smith, 1884.)

Section IV.—Chemical Examination.

This may be either qualitative or quantitative. For ordinary purposes, as for example, in the discharge of a medical officer of health's duties in rural districts, a qualitative examination, if judiciously conducted, will be found to be quite sufficient to enable him to give a reliable opinion as to whether a water is fit for use or not in the great majority of instances, provided the water is not specifically polluted. But, in all cases in which qualitative tests indicate that a water is doubtful or suspicious, and in cases which are likely to lead to magisterial proceedings, it is necessary to submit the sample to a quantitative analysis more or less complete. A quantitative analysis is also required in the examination of public supplies, and in the case of any proposed new public supply it should be thorough in all its details.

But the main object which the sanitarian has in view is to determine whether or not any given water is dangerously contaminated with organic matter, and this, as I have already said, may be ascertained in the great majority of instances by a qualitative examination. After noting the various indications obtained from the physical examination previously described, and taking care that all test-tubes, test-glasses, measures, and the like are thoroughly clean and conveniently arranged, the qualitative testing of one or more samples may be readily conducted as follows:—

1. *Qualitative Examination.*

(1.) *Ammonia.*—Fill an ordinary test-tube of about 1 oz. in capacity nearly full with the water to be

examined, and then add a few drops of the Nessler re-agent. If a yellow or brown colour, or a brownish precipitate, be produced, the water contains ammoniacal salts. As a rule, this should be regarded as a very suspicious circumstance, and should the coloration be well marked, it is almost sufficient of itself to condemn the water for drinking purposes. A milky or curdy-looking precipitate will also indicate that the water is hard. If the precipitate is excessive, it masks, to a certain extent, the colour indicative of the test, in which case it is advisable to take a fresh sample in another test-tube, add a few drops of a strong solution of caustic potash, and after the precipitate which is thus formed subsides, add the Nessler re-agent.

(2.) *Nitrites.*—Fill an average-sized test-glass about three parts full of the water to be examined, then add 5 minims of pure sulphuric acid and 5 minims of a solution of potassium iodide (5 grs. to 1 oz. distilled water), and afterwards pour in a small quantity of freshly-prepared starch solution. The solution is best prepared by rubbing one part of starch with 20 parts of boiling water. The liquid is then filtered, boiled, and, after being allowed to stand for twenty-four hours, the clear liquid is syphoned off. A blue tint indicates nitrites, and should the colour be at all deep the water is scarcely fit to drink. As iodide of potassium sometimes contains iodate, it is always advisable to make a comparative experiment either with distilled water or with a water which is known not to contain nitrites. Instead of the sulphuric acid, acetic acid may be used, and the starch paste, potassium iodide, and acid may be mixed before adding the solution to the water.

(3.) *Nitrates.*—The readiest method of testing for nitrates is that known as Horsley's test, of which the following modification has been proposed by Dr. Bond of Gloucester:—Put 20 minims of pure sulphuric acid into

a very small test-tube, then add 10 minims of the water to be examined, and afterwards drop in carefully 1 drop of a solution of pyro-gallic acid (10 grs. to 1 oz. distilled water acidulated with 2 drops of sulphuric acid). A pink zone, or sometimes a delicate blue zone changing into a dark amethyst tint, and from that into a brown tint, indicates nitrates. When shaken up, the greater part of this coloration may disappear for a time, but it gradually returns, and after the mixture has stood for a few hours a permanent tint is developed.

The detection of nitrates in a water derived from a deep well is no evidence of sewage contamination, because, as in the chalk formation, they may be derived from the strata through which the water passes, but in surface or shallow well waters their presence may fairly be regarded as a suspicious circumstance.

(4.) *Chlorides.*—The amount of chlorine in water can be determined so quickly by a simple volumetric method, which will be subsequently described, that those who are provided with the test-solution of nitrate of silver should always adopt this method; but to those who have not this test-solution the following method is recommended:—Acidulate a little of the water in a test-glass with a few drops of dilute nitric acid, and add in excess a solution of nitrate of silver. Four grains per gallon of sodium chloride give a turbidity; 10 grains a slight precipitate; and 20 grains a considerable precipitate, soluble in ammonia. A good water should only yield a slight haziness. If there is a distinct precipitate, it shows that the water is derived from a formation rich in salt, such as the new red sandstone, that it is brackish if on the sea-coast, or that it has been contaminated with sewage. In the first two cases there will be a large amount of mineral solids, and therefore, in the case of a soft water, any excess of chlorides would point to sewage contamination. On the other hand,

it is important to note that the absence of chlorides from a sample of water renders it very probable that it is free from sewage contamination.

(5.) *Lead and Iron.*—Boil between 3 and 4 oz. of the water acidulated with a few drops of sulphuric acid, and afterwards add sulphuretted hydrogen water. If a brown or blackish coloration is produced, the presence of lead may be inferred. If no colour can be detected, add a little potash or ammonia, and if this produces a blackish precipitate, iron is almost certain to be present. Small traces of iron in a water cannot be considered injurious, but the presence of lead is sufficient to condemn the water as unfit for use.

(6.) *Organic Matter.*—Although the permanganate of potash test has of late years fallen into disfavour with many analysts on account of its indefinitiveness, I am still of opinion that it may be employed with considerable advantage in the qualitative examination of surface-well waters, and particularly in localities where salts of iron are not usually found. The following is a convenient method of applying the test:—Fill a tall colourless glass vessel nearly full with the water to be examined, and add as much solution of potassium permanganate (2 grs. to 4 oz. distilled water) as will impart a distinct pink tinge after stirring with a glass rod. Then fill another glass cylinder of the same size with distilled water, and add the same quantity of permanganate solution. Stopper the two glasses and place them side by side on a white sheet of paper or porcelain slab, and note any differences between the two tints which may speedily or subsequently take place. If decoloration takes place rapidly, or sets in gradually, it shows that the water contains oxidisable organic matter, iron, nitrites, or sulphuretted hydrogen. The last of these is rarely found, and would be distinguished by the smell, while the presence of iron

or nitrites can be ascertained by tests already described. In the absence of these three any rapid decoloration indicates that the organic matter is of animal origin, whereas slower changes indicate that vegetable matter is present. With these limitations, and with a general knowledge of the geological characteristics of the well waters of a district, the test may be advantageously employed as a confirmatory test, though it cannot always be relied on when it gives negative results.

By a judicious application of some or all of these tests the medical officer of health can examine several samples of water in a comparatively short space of time; but, in order to conduct the examination systematically, he ought to arrange the test tubes or glasses in separate sets, and number them according to the samples. These, it is presumed, are all derived from surface or shallow well waters, and the following indications will enable him to decide as to whether the water is fit for use or not, or whether it is of doubtful purity, in which case it should be submitted to a quantitative analysis:—

If the water contains a considerable amount of sediment, and is found when decanted off or filtered to show little or no traces of ammonia, nitrites, or chlorides, it shows that it is fit for use, but the well requires cleaning out; or, should the well be a tube well, that it ought to be filtered. If the sediment is flocculent and dirty-looking, it will generally be found that the water is polluted in other respects, and an order should be given that the well should be opened, examined, and cleaned out, and any ascertained source of pollution removed. In towns or villages where there is a public water-supply, and the premises are within easy reach of a water-main, there should be no hesitation in requiring the well to be closed; or if the ground is so saturated with filth from leaky drains or cesspits that it is hopeless to expect that any

alterations can ensure subsequent safety, an order to close the well should still be insisted on. But supposing the water is tolerably clear, or quite clear, what are the inferences to be drawn from the qualitative examination? If there is distinct coloration on the addition of the Nessler re-agent, but very little precipitate, and with no distinct indications of either nitrites, nitrates, or chlorides, it shows that the water is a soft water and fit for use, and that the ammonia is either derived from rain water or is probably of vegetable origin. If ammonia, nitrites, and chlorides in excess are all present, the water is polluted and unfit for use. A water with no great excess of chlorides, and which yields a large flocculent precipitate on the addition of the Nessler re-agent, but does not become tinted, and gives no indication of the presence of nitrites, nitrates, or organic matter, is a hard water, but otherwise fit for use. Should a water contain nitrates and traces of nitrites, but give no distinct indication of ammonia or chlorides, it may be considered fit for use. If nitrites and chlorides are both present in any excess, the waters should be regarded as a very suspicious water, and be submitted to a more careful examination, even though the Nessler re-agent should produce no distinct coloration. But it should always be remembered that chemical analysis, however complete, can only indicate danger when palpably present,—it is powerless to indicate any standard of safety when a water becomes specifically polluted.

In giving instructions as to what action should be taken when a sample of well-water is found to be polluted, it is always advisable, when there is no public supply within reach, to recommend that the well should be opened and examined. The pollution may arise from want of cleansing, or from leakage from a drain, cesspool, or farmyard, and it will depend upon the special circum-

stances of the case as to whether cleansing and removal of the source of pollution will suffice, or whether the well should be closed altogether, and a new one sunk in some other suitable place where there is no risk of pollution. It is evident, therefore, that detailed information with regard to the situation and surroundings of a polluted well is of very material service in advising as to what particular steps should be taken; but, so far as the water itself is concerned, the medical officer of health need only report that it is contaminated and unfit for use. Should his recommendations, when notified in the regular way by the sanitary inspector, not be complied with, it may become necessary to submit the water in question to a quantitative analysis, in order to obtain a magistrate's order to cleanse, repair, or close the well, as the case may be.

2. *Quantitative Analysis.*

With the exception of proposed new public supplies, which should in all cases be submitted to a very minute analysis, the only points which require determination in an ordinary quantitative analysis are the total solids, the hardness, the chlorides, and the organic matter as represented by the free and albuminoid ammonia. If deemed necessary, additional evidence as regards the quality of a water will be obtained by determining the amount of oxygen absorbed, the amount of nitrogen existing as nitrates and nitrites, and, qualitatively, the amount of phosphates.

(1.) *Total Solids.*—The amount of total solids is ascertained by evaporating a known portion of the water to be examined to dryness. Into a platinum dish which has been carefully cleaned, dried, and weighed, pour 70 cubic centimetres of the sample of water; place the dish over a ring burner, and evaporate down to a small

quantity, taking care that there is no simmering or boiling, then evaporate to dryness in a water-bath, wipe the dish externally, and weigh. The difference between the two weighings gives the weight of the residue yielded by 70 cubic centimetres of water. Seventy c.c. are taken, because each milligramme of residue counts for one grain of total residue in a gallon of water, inasmuch as a gallon of water weighs 70,000 grains, and 70 c.c. weigh 70,000 milligrammes.

If the operator has a very delicate balance, and has had some experience in chemical manipulation, 25 c.c. of the water to be examined will usually be found sufficient, provided the water contains an average amount of solids in solution, but in that case the result in milligrammes must be multiplied by 2·8 (4 × ·7) in order to obtain the total amount of residue in grains per gallon. Thus, to take the following example :—

Weight of dish . . .	24·286	grammes.
,, dish and residue .	24·295	,,
Therefore weight of residue =	·009	,,

But ·009 grammes are 9 milligrammes, and multiplying this number by 2·8 gives 25·2 grains as the amount of solid residue in a gallon of the water examined. If 100 c.c. are taken, the multiple will of course be ·7. The times occupied in the evaporation average about two hours for the 100 c.c., an hour and a quarter for the 70 c.c., and about half an hour when only 25 c.c. are evaporated. In drying the residue, the dish should be put into a hot-air bath, then allowed to cool, and weighed promptly afterwards to avoid deliquescence of the salts. As soft waters yield a very insignificant residue, at least a quarter of a litre would be required for evaporation.

The total solid residue consists for the most part of mineral matter, and in many waters this is composed

chiefly of carbonate of lime. It is difficult to fix the maximum amount of permissible solid residue in drinking water. In public supplies it certainly ought not, if possible, to exceed 30 grains per gallon, but many usable well-waters are found to contain double this amount.

The following are examples of the amount of solids in different waters :—

	Grains per Gallon.
Loch Katrine	2·30
Bala Lake	3·18
London Thames Companies . . .	21·66
Rochdale spring	25·93
Norwich artesian well	26·70

If a complete quantitative analysis of the saline constituents is required, a much larger quantity of water must be evaporated, but the presence and amount of the more important constituents may be approximately determined as follows :—

a. Lime.—Pour a little of the water into a test-glass, and add a solution of ammonium oxalate. Six grains of lime per gallon will yield a slight turbidity; 16 grains a distinct precipitate; and 30 grains a large precipitate, soluble in nitric acid.

b. Magnesia.—In a good water there should only be a slight haziness, or none at all, on the addition of ammonia.

c. Sulphates.—Acidulate with a few drops of hydrochloric acid and add a solution of barium nitrate. A good water should not give more than a slight haziness.

It is seldom, however, that these subsidiary tests are required. A more important indication is obtained by incinerating the residue over a flame, when, if blackening occurs, the presence of organic impurities may be inferred, and should a bad smell be given off at the same time, it is almost certain to be derived from impurities of animal origin. The dish may be again cooled and weighed, when

the loss of weight is returned as loss on ignition, and the final residue may be used for the qualitative determination of phosphates when that is deemed necessary.

(2.) *Hardness.*—It has already been pointed out that a water is hard or soft according to the amount of solid residue which it contains. Thus a water which contains only three to four grains of residue, such as the Loch Katrine water, is an exceedingly soft water; a water containing eight to ten grains is a moderately soft water; while those which contain twenty grains and upwards are hard waters. For purely sanitary purposes, therefore, the determination of the hardness is seldom required, if the total solid residue has been ascertained. The hardness of a water is due to the presence of earthy salts, generally carbonate of lime and sulphate of lime and magnesia. The former is deposited on boiling, and is represented by what is called the removable hardness, while the latter, inasmuch as it is not affected by boiling, is called the permanent hardness. The *rationale* of the process, as first explained by the late Professor Clark, will be understood when it is remembered that if an alkaline oleate, such as soap, is mixed with pure water, a lather is formed almost immediately; but if salts of lime, magnesia, baryta, iron, or alumina are present, oleates of these bases are formed, and no lather is given until the earthy bases are thrown down. As the soap will combine in equivalent proportions with these bases, it is only necessary to make the solution of soap of known strength by standardising it with a known quantity, say of chloride of calcium, to be able to determine the amount of lime or its equivalent of other salts in the water—so much soap required before a lather is produced represents so many degrees of hardness. The standard solutions are prepared and determined according to the following method, proposed by Messrs. Wanklyn and Chapman:—Make a solution of

pure calcium chloride of 1·110 grammes to the litre of distilled water, or preferably weigh 1·0 gramme of commercial precipitated calcium carbonate dried at 300° Fahr., dissolve in slight excess of pure hydrochloric acid, evaporate to dryness, and make up to litre with distilled water. Each cubic centimetre of either solution is equivalent to one milligramme of carbonate of lime. The standard soap test is made by pounding together two parts of lead plaister with one of carbonate of potash, exhausting repeatedly with alcohol at 90 per cent, and using about thirty times as much alcohol as lead plaister. This solution is allowed to stand for some time, and is then filtered, and afterwards diluted with its own volume of water. In order to standardise it, 10 c.c. are taken and put into a bottle with 70 c.c. of pure water; the chloride of calcium solution is now added until frothing stops, care being taken to shake properly; and from this trial experiment it is easy to calculate how much dilution of the soap solution is requisite in order to make 17 c.c. of the soap test use up 16 c.c. of the chloride of calcium solution. The dilution should be made with alcohol of 50 per cent, and the soap test carefully verified after it has been made up. This is done by adding 16 c.c. of the standard solution of calcium chloride to 54 c.c. of distilled water, thus making a solution of 70 c.c., which should exactly be neutralised by 17 c.c. of the standard soap test.

A much easier method of making the soap test, and one which gives fairly accurate results, is to dissolve ten grammes of green Castile soap in a litre of weak alcohol of about 35 per cent. One cubic centimetre of this solution also precipitates one milligramme of carbonate of lime. Either solution, therefore, may be used, and the mode of employing the test is as follows:—

Into a clear glass-stoppered bottle, capable of holding

about 250 c.c. put 70 c.c. of the water. Add slowly from a burette the standard soap solution, and shake well until a persistent lather is formed, when the bottle is laid on its side, noting accurately the amount of solution used. Each c.c. of the solution consumed indicates one grain of carbonate of lime or its equivalent in a gallon of water. If, after adding 17 c.c. of the solution, no lather is formed, add 70 c.c. of distilled water and mix, and continue the addition of the soap solution. Should no lather be formed until other 17 c.c. are consumed, other 70 c.c. of distilled water must be added, but in making the calculation for hardness 1 must be deducted from the number of c.c. of soap solution used for each 70 c.c. of water which have been added, and this deduction is necessary because 70 c.c. of distilled water would themselves neutralise about 1 c.c. of soap test. Suppose, for example, that 18 c.c. of soap solution have been required, then 1 must be deducted from the 70 c.c. of distilled water which were added, and the hardness of the sample in question is put down as 17 degrees. In other words, the total soap-destroying power of the water is equivalent to 17 grains of carbonate of lime per gallon. The permanent hardness is obtained by boiling 70 c.c. of the water for about an hour, and making up the loss by evaporation with distilled water. During boiling, the bicarbonate of lime is decomposed and the carbonate deposited, and thus the water becomes softer. After allowing to cool and filtering, the permanent hardness is determined in the same way as the total hardness, and the difference between these two, as already stated, is the removable hardness.

According to Wanklyn's method, the degrees of hardness represent "the potential carbonate of lime," and in translating them into Clark's degrees it is necessary to deduct 1. Thus, in the above example,

the degrees of hardness, according to Clark's standard, would be 16.

Altogether, the importance of this test has been greatly over-estimated, and it is seldom that the medical officer of health will deem it necessary to employ it.

(3.) *Chlorides.*—The estimation of chlorine as chlorides in water can be readily determined volumetrically by means of chromate of potash and a standard solution of nitrate of silver. This solution is prepared by dissolving 4·79 grammes of dry nitrate of silver in a litre of distilled water. As chromate of silver is soluble in acids, it is necessary that the nitrate of silver used should be neutral. Each c.c. of this solution precipitates 1 milligramme of chlorine. Seventy c.c. of the water to be examined are put into a beaker or evaporating dish, and a small crystal of pure chromate of potash, or a few drops of a strong solution of this salt added, sufficient in either case to produce a distinct yellow tint. The standard solution is then dropped carefully in from a graduated pipette or burette, and directly the first faint tinge of red is discernible and remains permanent on stirring, the whole of the chlorine is precipitated, and chromate of silver, which is a dark red, is formed. The number of c.c. of the solution used before this red tinge is obtained represents the number of grains of chlorine per gallon of water. If, for example, 3·5 c.c. of this solution have been required, the water contains 3·5 grains of chlorine per gallon.

The following are examples of the amount of chlorine in different waters :—

	Grains per Gallon.
Thames at Kew	·847
Thames at London Bridge . . .	4·452
Bala Lake	·706
Polluted well at Rugby . . .	7·5

The indications afforded by the chlorine test have previously been dwelt upon in the remarks on the quali-

tative examination of water, and they need not therefore be further referred to here.

(4.) *Ammonia and Organic Matter.*—Of the two rival methods of estimating the organic matter in water—namely, that of Frankland and Armstrong, and that devised by Wanklyn, Chapman, and Smith—there is a general concurrence of opinion that the latter is especially suited for the medical officer of health, because it is easy of application, and, so far as chemical analysis can at present indicate, yields sufficiently accurate results for ordinary hygienic purposes. Frankland's process of estimating the organic carbon and nitrogen is a method of no small difficulty, and in the hands of any but an experienced chemist the risk of experimental error is very considerable. What is known as the *Ammonia process,* therefore, will be the process described here. For a full description of this process the reader is referred to Mr. Wanklyn's excellent text-book on water analysis, from which the following remarks are for the most part collated. The *rationale* of the process depends upon the fact that vague and indefinite nitrogenous bodies can be converted into a definite compound, namely ammonia, and that in this way they can be estimated and expressed as ammonia. Owing to the excessive minuteness of the quantities of nitrogenous compounds which distinguish between a good and a bad water, it is convenient to adopt a much finer scale of measurement than is requisite for the saline constituents; and the amount of ammonia is accordingly expressed by milligrammes per litre, or so many parts in a million. The re-agents which are employed are the Nessler test, a standard solution of ammonia, a saturated solution of carbonate of soda, and a solution of potassium permanganate and caustic potash.

a. Nessler Test.—Dissolve, by heating, 35 grammes of iodide of potassium and 13 grammes of corrosive subli-

mate in about half a litre of distilled water, and afterwards add gradually a cold saturated solution of corrosive sublimate, and keep stirring until the red colour produced begins to be permanent. Then add 160 grammes of caustic potash dissolved in about 200 c.c. of distilled water, and dilute with sufficient water to bring the whole up to a litre. To render the test sensitive, add about 20 more c.c. of the saturated solution of corrosive sublimate, and allow it to stand in a stoppered bottle until the precipitate has subsided. The clear liquid may now be decanted and kept in a tightly stoppered stock bottle ready for use.

b. Standard Solution of Ammonia.—Dissolve 3·15 grammes of crystallised sal-ammoniac or ammonium chloride in one litre of distilled water. Every cubic centimetre of this solution contains one milligramme of ammonia. This is termed the strong solution, and is the most convenient to keep. To prepare the dilute solution, put 5 c.c. of the strong solution into a half-litre flask, and fill up with distilled water. This is the standard solution of ammonia, and contains 0·01 milligramme of ammonia in 1 c.c. of water.

c. The Saturated Solution of Carbonate of Soda may be prepared by boiling an excess of the common carbonate in distilled water. About 10 c.c. of this solution is the proper quantity to use, or instead of the solution about one gramme of the dry carbonate of soda, which has just been ignited, may be employed. The carbonate of soda is used in order that the free ammonia may be more easily dispelled on distillation.

d. The Permanganate of Potash and Caustic Potash Solution is prepared as follows:—Dissolve 8 grammes of crystallised permanganate of potash, and 200 grammes of solid caustic potash in one litre of distilled water. Boil the solution for some time to free it from all traces of

ammonia, and afterwards replace the water lost by evaporation by adding sufficient distilled water to make up the litre.

The distilled water which is used to make up the various solutions may be obtained of sufficient purity from any common drinking water, if care is taken to reject the first portions of distillate, and the distillation is not pushed too far. It should always be carefully tested before being used, and so chemically pure that in 100 c.c. there ought not to be 0·005 milligramme of ammonia.

The following is a list of the apparatus required for the process:—A stoppered retort, capable of holding at least one litre; a Liebig's condenser; a good-sized Bunsen's lamp or burner; a retort-holder; about half a dozen Nessler glasses made of white glass, and with a mark at 50 c.c.; a half-litre flask; a graduated burette marked into c.c., to measure off the standard solution of ammonia; and a pipette marked to hold 2 c.c. It need hardly be said that the greatest care must be taken to have the whole of the apparatus thoroughly clean before it is used. Glass vessels should first be washed out with a little strong hydrochloric or sulphuric acid, and afterwards with pure water.

The analysis itself is thus performed:—After mounting the retort on the holder, and properly connecting it with the Liebig's condenser, half a litre of the water to be examined is poured into it, and 10 c.c. of the solution of carbonate of soda added. The Bunsen lamp is now lighted, the retort thrust well down into the flame, and 50 c.c. are distilled over into a Nessler glass, and *Nesslerised.* Then distil over 150 c.c. and throw this distillate away. This amount is thrown away because it has been found that the first distillate contains exactly three-fourths of the free ammonia present in the water, and it is therefore a waste of labour to Nesslerise the whole of

the four 50 c.c. distilled over. There are now 300 c.c. left in the retort, and in order to liberate the "albuminoid ammonia," 50 c.c. of the permanganate of potash and caustic potash solution are poured into the retort by means of a wide funnel. To prevent bumping, which is very liable to occur with a bad water, the retort should be gently shaken, so as to give the mixture a wavy motion. The distillation is then continued, and three separate distillates, each of 50 c.c., taken and Nesslerised.

What is called Nesslerising is the process of ascertaining the strength of a dilute solution of ammonia by means of the Nessler re-agent, and is indeed one of the most beautiful examples of colorimetric analysis. Let the first distillate of 50 c.c. be taken as an illustration. To this distillate, which is contained in one of the Nessler glasses, 2 c.c. of the Nessler re-agent are added by means of the 2 c.c. pipette, which also serves as a convenient stirrer. If, after stirring and waiting about a couple of minutes, the liquid assumes a rich deep brown, it contains much ammonia; if even a distinct brown tint is developed, it contains a considerable quantity of ammonia; but if it remain colourless, it does not contain so much as ·005 milligramme. When only a light-yellowish tint is produced, the amount of ammonia present is comparatively small. In any case, however, the exact amount is determined by comparing with a known solution of ammonia. The depth of tint in the distillate is imitated by mixing, in a Nessler glass, more or less of the dilute standard of ammonia contained in the burette with distilled water, and filling up to 50 c.c., and then adding 2 c.c. of the Nessler re-agent. If, after stirring and waiting two or three minutes, the tint developed in the artificially prepared solution is too dark or too light, it is necessary to make another artificial solution of less or greater strength, as the case may be. With a little practice it

is easy to approximate very closely to the exact amount of the standard solution of ammonia which will be required to produce a tint on the addition of 2 c.c. of the Nessler re-agent, which will harmonise completely with the tint of the distillate. In order to be able to compare the tints accurately, the Nessler glasses should be placed on a white porcelain slab or sheet of white paper. The number of cubic centimetres of the standard solution of ammonia, which on the addition of the Nessler re-agent were required to reproduce the exact tint given by the distillate, are noted, and the amount of "free ammonia" contained in the sample of water can then be readily calculated.

The other three distillates which contain the albuminoid ammonia are Nesslerised in the same way, and the amount of the standard solution of ammonia, which was required to imitate the tint in each case, is also noted. These several amounts added together represent the total "albuminoid ammonia" contained in half a litre of the water. It has already been pointed out that the first 50 c.c. which were distilled over contain three-fourths of the whole of the "free ammonia," and that therefore the next 150 c.c. distilled over may be thrown away. It was formerly the practice of Mr. Wanklyn to Nesslerise the whole four 50 c.c. to obtain the total of the free ammonia, but the amount contained in the first distillate was found to bear such a constant ratio to the amount contained in the other three distillates, namely, as 3 to 1, that it becomes a needless expenditure of labour to Nesslerise them. The rule, therefore, is to add one-third to the amount of ammonia found in the first distillate, in order to obtain the whole of the free ammonia.

Remembering now that each cubic centimetre of the standard solution contains ·01 milligramme of ammonia, the calculation in any given case becomes very simple.

For example, suppose the amount of dilute standard solution of ammonia required to match the tint in each case to be as follows :—

Free ammonia distillate		2 c.c.
Albuminoid ammonia	1st distillate	5 ,,
	2d ,,	2·5 ,,
	3d ,,	·5 ,,

then we arrive at the following amounts :—

	Milligrammes.
Free ammonia = ·02 + $\frac{·02}{3}$ =	·027
Albuminoid ammonia — 1st distillate	·05
Albuminoid ammonia — 2d ,,	·025
Albuminoid ammonia — 3d ,,	·005
Total albuminoid ammonia	·08

But, inasmuch as half a litre of water was taken for analysis, these results must be multiplied by 2 in order to arrive at the amounts per litre, or per million parts. In the above example, therefore, the results would be stated as follows :—

	Parts in a Million, or Milligrammes per Litre.
Free ammonia =	·054
Albuminoid ammonia =	·16

In this process of water analysis it will be observed from the above description that ammonia is to be looked for at two stages : firstly, in distilling off with the carbonate of soda solution ; and secondly, on distilling off with the alkaline permanganate solution. The first portion of the ammonia is called the " free ammonia," because it is obtained from the decomposition of those organic impurities in water which are of simple constitution, such as the ureal class, as well as the ammonia which may be present as ammonia. The second portions of ammonia are named " albuminoid ammonia," because the ammonia which is given off is derived from the oxidation of those more com-

plex nitrogenous impurities which are closely allied to albumen.

The following are examples of pure, indifferent, and bad samples of water, as determined by the ammonia process :—

	Free Ammonia, parts per 1,000,000.	Albuminoid Ammonia, parts per 1,000,000.	Quality.	Name of Authority.
Loch Katrine . .	·004	·08	Good	Wanklyn
Water from Kent Company's mains . .	·01	·02	,,	,,
Edinburgh Water Supply, Colinton, 1867 .	·14	·08	Indifferent	,,
Great St. Helen's pump, London . . .	3·75	·18	Bad	,,

With regard to the inferences which may be deduced concerning the quality of a water as indicated by this method of examination, Mr. Wanklyn has laid down the following rules in the third edition of his work on water analysis :—"If a water yield ·00 parts of albuminoid ammonia per million, it may be passed as organically pure, despite of much free ammonia and chlorides ; and if, indeed, the albuminoid ammonia amount to ·02, or to less than ·05 parts per million, the water belongs to the class of very pure water. When the albuminoid ammonia amounts to ·05, then the proportion of free ammonia becomes an element in the calculation ; and I should be inclined to regard with some suspicion a water yielding a considerable quantity of free ammonia, along with ·05 parts of albuminoid ammonia per million. Free ammonia, however, being absent or very small, a water should not be condemned unless the albuminoid ammonia reaches something like ·10 per million. Albuminoid ammonia above ·10 per million begins to be a very suspicious sign ; and over ·15 ought to condemn a water absolutely."

But the experiments of Dr. Cory, to which reference is made at the close of this chapter, prove clearly that polluting matter, potent for harm, may be present in water which, according to Wanklyn's analysis, may be passed as organically pure, and hence it is of the utmost importance that the surroundings and possible sources of pollution of a particular supply should always be carefully taken into consideration. No matter what process may be adopted, whether Wanklyn's, Frankland's, or Tidy's, water analysis can only indicate degrees of impurity and danger, not standards of purity and safety.

On the other hand, it must be admitted that there are many surface well-waters in country districts containing even more than ·15 parts per million of albuminoid ammonia, and to which no bad effects can be traced, but in these cases it is probable that the ammonia is chiefly derived from vegetable matter. If the quantity of chlorine found in a water is exceedingly small, any excess of albuminoid ammonia would indicate that the nitrogenous matter present is of vegetable and not of animal origin, and therefore comparatively innocuous. At the same time it should be remembered that there might be the same absence of chlorine if the water becomes polluted from the presence of the body of a dead animal in a well or cistern.

(5.) *Nitrogen existing as Nitrates and Nitrites.*—Several processes have been recommended for the estimation of the nitrogen existing in water as nitrates and nitrites, but the one most generally adopted is that known as the copper-zinc process. What is called the copper-zinc couple is best prepared as follows :—Take a piece of pure zincfoil about 2 inches wide and 4 inches long, cleanse thoroughly, then insert into a wide-mouthed stoppered bottle of 250 c.c. capacity containing sufficient quantity of 3 per cent solution of cupric sulphate to cover the foil.

Allow foil to remain in solution until there is a firm bronze-looking coating of copper deposited, then carefully pour off solution and thoroughly wash, first with pure water by refilling bottle, then empty and wash with the water to be analysed. Empty once more, and finally refill with the water to be examined, add ·5 gramme of pure oxalic acid, and having inserted the stopper, allow it to remain either in the cold for twenty-four hours, or in a water-bath at from 130° to 140° Fahr. for two hours. The oxalic acid is added to expedite the process and to form insoluble salts of calcium and zinc. If the water does not contain any salts of magnesium, either 5 or 10 c.c. of the clear water may be drawn off with a pipette, made up to 50 c.c., and Nesslerised at once in the usual way; but if magnesian salts are present it is necessary to draw off 50 c.c., make up to 250 c.c. with pure distilled water, rendered alkaline with pure caustic soda, and distilled until the last distillate of 50 c.c. is free from ammonia.

From the total amount of ammonia contained in the distillates deduct the quantity of ammonia which has been found to exist in the water as free ammonia, and calculate the amount of nitrogen represented by the difference between the two. For example, 70 c.c. of the water after treatment is distilled as above directed.

	Milligrammes of Ammonia.
1st distillate of 50 c. c. yields . . .	·85
2d „ „ „ . . .	·08
3d „ „ „ . . .	·01
Total	·94

Now, suppose that the free ammonia found to exist in the water amounts to ·0098 milligrammes in 70 c.c., then

	Milligramme.
·94 – ·0098 =	·9302

In order to convert the ammonia into its equivalent of nitrogen the following will be the formula, where N represents nitrogen and NH_3 ammonia :—

$$\frac{NH_3 \times 14}{17} = N,$$

or, in this instance,

$$\frac{\cdot 9302 \times 14}{17} = \cdot 766 \text{ milligrammes.}$$

But as 70 c.c. of the water were taken for estimating the nitrogen, the resulting milligrammes of nitrogen will represent grains per gallon, or ·766 grains per gallon.

With regard to the amount of nitrogen existing as nitrates and nitrites in different waters, the following data will be useful :—

	Grains per Gallon.
Spring water	·2
London Water Companies . . .	·26
Some wells from the chalk . . .	·6 to ·7

Any water not derived from the chalk formation containing more than ·7 grains of nitrogen per gallon would be regarded as suspicious, while if the amount reached 1·5 the water would be considered dangerous for drinking purposes.

(6.) *The Oxygen or Permanganate Process.*—The *rationale* of this process, which is known also as the Forschammer process, consists in estimating the quantity of oxidisable matter contained in a water by the amount of oxygen absorbed.

The re-agents required are :—

a. Permanganate Solution.—Dissolve ·395 gramme of pure potassium permanganate in 1 litre of distilled water. Each c.c. contains ·0001 gramme of available oxygen.

b. Potassium Iodide Solution.—Dissolve 1 part of pure potassium iodide in 10 parts of distilled water.

c. Dilute Sulphuric Acid.—One part by volume of pure sulphuric acid is mixed with 3 parts by volume of pure distilled water.

d. Sodium Hyposulphite.—One part of crystallised sodium hyposulphite dissolved in 1000 parts of water. This solution must always be standardised at the time of using and corrected so that 10 c.c. shall be equivalent to 10 c.c. of the permanganate solution.

e. Starch water.

The process is then conducted as follows :—

Select two securely stoppered bottles of about 500 c.c. capacity, and introduce into each 250 c.c. of the water to be examined, then add to each 10 c.c. of dilute sulphuric acid and 10 c.c. of standard permanganate solution discharged from a suitable burette. Insert the stoppers and place the bottles in a water-bath at 80° Fahr., and maintain that temperature for four hours. Two separate determinations are made, viz., the amount of oxygen absorbed at the end of fifteen minutes, and that absorbed during the whole four hours, each titration being conducted as follows :— At the end of fifteen minutes one bottle is removed from the water-bath, and a few drops of potassium iodide solution are added to remove the pink colour. After thoroughly mixing, the standard sodium hyposulphite solution is then run in until the yellow colour is nearly destroyed, after which a little starch water is added, and the titration continued until the water is colourless.

Example :—At the end of fifteen minutes from the time of adding the 10 c.c. of permanganate solution the bottle is removed from the water-bath, a few drops of potassium iodide solution added, and titrated with hyposulphite solution. Now, suppose that the amount required is 7·2 c.c., then,

10 c.c. − 7·2 c.c. = 2·8 c.c. of permanganate solution consumed by 250 c.c. of water,

∴ 2·8 c.c. × 4 = 11·2 c.c. of permanganate solution consumed by 1 litre of water ; but

11·2 × ·0001 (co-efficient for oxygen) = ·00112 gramme or 1·12 milligramme of oxygen consumed by 1 litre in fifteen minutes,

= ·0784 grains of oxygen consumed by 1 gallon of the water in fifteen minutes at 80° Fahr.

At the end of four hours the contents of the other bottle are titrated in a similar manner, and the results expressed in the same way.

The inferences to be drawn from this process may be briefly stated as follows :—After four hours the amount of oxygen consumed should not exceed 1·0 milligramme per litre in a good water ; if it exceeds this amount, and is under 1·5, the water is usable ; but if this latter amount is exceeded the water is either suspicious or bad. It is also worthy of note that a bad or suspicious water is found to consume more than three times as much oxygen in the four hours as during fifteen minutes.

(7.) *Estimation of Phosphoric Acid.*—Take the residue which has been incinerated after weighing, moisten with strong nitric acid, and evaporate to dryness in a water-bath to render the silica insoluble. It is now again dissolved in dilute nitric acid, and passed through an exhausted filtered paper. If the filtrate exceeds 5 c.c. it should be concentrated by evaporation below this quantity. The filtrate is now tested qualitatively by the molybdic solution as follows :—Add to filtrate an equal volume of solution and warm gently. According to the depth or amount of decided precipitate phosphates are returned as " traces," " heavy traces," and " very heavy traces."

The molybdic solution is thus prepared :—Molybdic acid, 1 part ; ammonia sp. gr. ·960, 4 parts ; nitric acid sp. gr. 1·2, 15 parts. The molybdic acid is dissolved in the ammonia, filtered, and poured with constant stirring into the nitric acid.

In conducting a water analysis it is expedient, if the amount of solids is to be taken, to commence the evaporation for the solids first, then to commence distilling for the ammonia, and while the evaporation and distillation are going on, to determine the amount of chlorides, and the degree of hardness, if that be considered necessary. Afterwards, if deemed advisable, the nitrogen existing as nitrates and nitrites, the amount of oxygen consumed, and the phosphoric acid may be determined. It need hardly be said that a detailed record of the results of every analysis should be kept in a book set apart for that purpose. The form of report or certificate will of course vary according to the number of data and the mode of analysis, but the following hints will indicate generally how it should be drawn up :—

Date of reception of sample, size and description of bottle or bottles, how stoppered or sealed, and how labelled.

Physical Examination.

Appearance .	(Clear, or slightly turbid, etc.)
Taste . .	(Tasteless, or unpleasant, etc.)
Odour . .	(Odourless, fœtid, etc.)
Deposit . .	(Slight or large, dirty-looking, flocculent, etc.)

Microscopic Examination.

(Sandy particles, vegetable matters, animal matters, vibriones, etc.)

Chemical Examination.

Qualitative results :—

Free ammonia .	(None—traces—large amount.)
Nitrites . .	(None—traces—large amount.)
Nitrates . .	(None—slight traces, etc.)
Sulphates . .	(None—slight traces, etc.)
Metals . .	(None—traces of lead, etc.)

Quantitative results :—

Total solids .	(In grs. per gallon.)
Chlorides . .	(In grs. per gallon.)
Free ammonia .	(Grains per gallon.)
Albuminoid ammonia	(Grains per gallon.)
Nitrogen existing as nitrates and nitrites	(Grains per gallon.)
Oxygen consumed by organic matter	(Grains per gallon.)
Phosphoric acid . .	(Traces, heavy traces.)
Hardness, total .	(In degrees.)
,, permanent	(In degrees.)

Remarks as to whether the water is soft or hard, of good quality and fit for use, or whether it is polluted and unfit for use.

Date of analysis,—signature, etc.

As it has become customary to express the results in grains per gallon instead of parts per million, the following formula will indicate the method of calculation :—

100 : 7 :: ·15 (parts per million) : ·0105 (grains per gallon).

Exclusive of the microscopic examination, which is seldom undertaken, an ordinary water analysis giving the total solids, chlorine, and free and albuminoid ammonia may be completed in about an hour and a half, provided, of course, that the operator is fairly expert at his work and has all his test and standard solutions prepared beforehand. The busy medical officer of health may obtain most of these solutions, as well as distilled water, from chemists, but he should always make blank experiments to test their purity and quality.

Although I have thus far endeavoured to describe clearly and concisely the various steps of an ordinary water analysis, I nevertheless consider it very essential that every one who has to undertake this kind of work should receive lessons in the laboratory of a competent analyst. If he is precluded from doing this, he may teach himself, provided that he has a sound knowledge of ele-

mentary and practical chemistry, but in this case he ought to experiment with samples obtained from a public supply, and compare his results with those of recorded analyses of that supply.

As already stated, any proposed new public supply should be submitted to a full quantitative analysis of its saline and other constituents, and for this purpose samples should be sent to a professed analyst. It should not only be usable, but the best which can be procured within the limits of reasonable expenditure. All waters subjected to filtration should be examined from time to time, to ascertain that the filtering process is carried on efficiently. Any water which gives indications of having become contaminated with animal or other impurities, and which has hitherto been good and wholesome, should be entirely disused until the source of contamination has been discovered and removed.

Concluding Remarks.—Although it must be admitted that the methods of water analysis which are now in use are capable of detecting very minute quantities of organic matter in large volumes of water, it must always be borne in mind, as previously pointed out, that chemical analysis however complete is powerless to indicate any standard of safety when a water becomes specifically polluted. The careful experiments conducted by Drs. Cory and Dupré, at the instigation of the Local Government Board, prove clearly that chemistry cannot tell whether a healthy or a diseased body has been the source of any excremental pollution of any particular water. Many of Dr. Cory's observations had special reference to experimental contamination of different waters,—some with healthy stools and some with the stools of enteric fever patients, and the results not only gave no indication as to whether the polluting matter came from a healthy or diseased body, but failed to indicate the presence of an

amount of specifically polluting matter which must have been far in excess of that which proved so disastrous in the well-known Caterham epidemic (see following Chapter). The lessons which may be learned from this inquiry are so ably summed up by Dr. Buchanan that I cannot do better than quote them here :—" While we must ever be on the watch for the indications that chemistry affords of contaminating matters gaining access to our waters, we must (at any rate until other methods of recognition are discovered) go beyond the laboratory for evidence of any drinking water being free from dangerous organic pollution. Unless the chemist is well acquainted with the origin and liabilities of the water he is examining, he is not justified in speaking of a water as 'safe' or 'wholesome,' if it contain any trace whatever of organic matter; hardly, indeed, even if it contain absolutely none of such matter appreciable by his very delicate methods. The chemist, in brief, can tell us of impurity and hazard, but not of purity and safety. For information about these we must go, with the aid of what the chemist has been able to teach us, in search of the conditions surrounding water sources and affecting water services."—(*Annual Report of the Medical Officer of the Local Government Board*, 1881-1882.)

What are known as the sugar process and Koch's gelatine process in detecting minute organisms in water open up a new and interesting field of inquiry, but they have not yet advanced to the stage of yielding sufficiently practical results to recommend their general adoption. Those who are interested in the subject will find much valuable information in the Second Report under the Rivers Pollution Act, by the late Dr. Angus Smith, published in 1884.

(8.) *Analysis of Sewage and Effluents.*—In analysing samples of sewage and effluents the same steps are

followed as in water analysis with the exception that as regards effluents it is advisable to estimate the matters in suspension. The estimation of the hardness is not necessary, and as nitrates and nitrites are speedily decomposed in sewage, the estimation of the nitrogen is obviously valueless. It need hardly be said that the character of any particular sample of sewage will vary very much according to the sanitary arrangements of the town, the nature and extent of manufactories, the amount of dilution by rainfall or subsoil water, the season of the year, the time of day at which the sample is collected, the amount of water-supply per head of the population, and other conditions; while the character of the effluent will be further influenced by the particular process of purification adopted, whether by a chemical process, by filtration, by irrigation, or by a combination of these systems. Much, too, will depend upon whether any particular process is fairly and carefully carried out.

In making an analysis it will generally be found that 50 c.c. of sewage diluted to about 300 c.c. with distilled water will be quite sufficient for the estimation of the free and albuminoid ammonia, while as regards effluents 250 c.c. will be found to be a convenient quantity to work with.

The following analysis of samples of fair weather sewage and effluents conducted conjointly by Mr. Spilsbury, F.C.S. of Leamington and myself, will show the variations in the character of sewage and the effects of purification by irrigation on the effluents. It will be noted that the Kenilworth sewage is not nearly so impure as the samples from the other towns; and that is accounted for by the fact that as the drainage of Kenilworth has only recently been carried out, there are comparatively few water-closets, whereas Leamington, Warwick, and Rugby are entirely water-closet towns.

Analysis of Sewages and Effluents expressed in grains per gallon.

		Total Solids.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Phosphoric Acid.	Suspended matter.
Warwick	Sewage . .	128·1	5·325	3·64	2·31	2·220	...
,,	Effluent .	47·6	3·905	1·204	·123	·716	...
Leamington	Sewage . .	91·1	11·00	13·342	·803	2·149	11·9
,,	,, .	95·9	9·05	7·532	1·344	1·97	18·2
,,	Effluent (1) .	58·8	5·60	·84	·1176	trace	...
,,	,, (2) .	49·7	4·4	·084	·0392	absent	...
,,	,, (3) .	51·1	4·4	·120	·0252	slight trace	...
Kenilworth	Sewage . .	36·4	3·4	·896	·042	heavy traces	...
,,	Effluent .	41·3	5·1	·196	·042	trace	...
Rugby	Sewage . .	68·6	7·5	3·51	1·092	1·074	21·16
,,	Effluent .	40·6	4·4	·728	·082	heavy traces	...
Birmingham	Sewage . .	165·9	44·5	2·156	·798	1·253	55·72
,,	,, .	104·3	14·5	3·514	1·078	1·253	37·52
,,	Effluent .	56·0	9·7	·364	·0448	absent	...
,,	,, .	55·3	9·7	·364	·0448	absent	...

Note.—Effluents (1), (2), (3), from the Leamington Sewage Farm, represent samples taken at the first outlet, then after the first effluent has passed through a filtering bed, and lastly from a brook into which this last effluent flows before discharging into the river Leam.

CHAPTER VIII.

IMPURE WATER, AND ITS EFFECTS ON PUBLIC HEALTH

ALTHOUGH impure water has long been recognised as one of the most potent causes of disease, it is only of recent years that minute investigation has succeeded in demonstrating the terrible mortality which it inflicts on all classes of the community. It is true that chemical analysis often fails in detecting the special impurities on which the development of certain diseases depends; it is also true that, even when impurities are detected, it is extremely difficult to estimate their exact etiological value; nevertheless, the broad fact remains, and it is founded on evidence of the most conclusive kind, that a vast number of cases of disease are attributable to the use of impure water, and there are good grounds for believing that, as investigations become more frequent and precise, a continually increasing class of such cases will be discovered. It must also be remembered that the effects of impure water, like the effects of impure air, may engender a general impairment of the health, without giving rise to well-pronounced disease.

Water impurities and their effects may be conveniently considered as follows:—Firstly, water rendered impure by an excess of mineral substances; secondly, water rendered impure by the presence of vegetable matter; thirdly, water rendered impure by animal organic matter.

Section I.—Water rendered impure by an Excess of Mineral Substances.

As all potable waters contain a certain amount of mineral matters, it is extremely difficult to decide the quantities of these ingredients which may be present, either singly or collectively, without producing bad effects. This much, however, may be said, that waters of a moderate amount of hardness, provided that the hardness depends chiefly on the presence of calcium carbonate, are not found to be detrimental to health. A water of 8 or 10 degrees of temporary hardness, equivalent to about as many grains per gallon of total mineral solids, may be pronounced good and wholesome, while one of as many degrees of permanent hardness would prove injurious to many persons. With regard to the wholesomeness of Thames water, with a hardness averaging 15 degrees before boiling and 5 degrees after, the evidence given before the Royal Commission on Water Supply, 1869, is somewhat conflicting; for while Dr. Letheby considered a moderately hard water, such as the Thames water, best suited for drinking purposes and the supply of cities, Dr. Parkes maintained that the amount of hardness should not exceed 10 or 12 degrees, if possible. Mr. Simon and Dr. Lyon Playfair, on the other hand, although they did not condemn the London water on account of its hardness, both expressed themselves in favour of a softer water for purposes of health. The inference that may be drawn from this and other evidence would therefore appear to be this, that the total hardness of a good water ought not to exceed 15 degrees, nor the permanent hardness 5; or, in other words, that even in a moderately hard water, calcium carbonate must always greatly exceed the magnesium and calcium sulphates and sodium chloride.

The symptoms referable to an excess of hardness, arising from the presence of earthy salts, are mainly of a dyspeptic nature. According to Dr. Sutherland, the use of the hard waters derived from the red sandstone rocks underlying Liverpool produced in many cases constipation and visceral obstruction, and an excess of calcium and magnesium sulphates (7 to 10 grains per gallon) has been known to produce diarrhœa.

The special disease, however, which, more than any other, seems intimately connected with the mineral ingredients of water is goitre. In some parts of England, such as Yorkshire, Derbyshire, Hampshire, and Sussex, it is found to prevail only in those districts where the magnesian limestone formation abounds. According to Dr. Coindet of Geneva, the disease is speedily produced in persons drinking the hard pump water in the lower streets of that town, while in other parts of Switzerland the use of spring water has been followed by the production or augmentation of the disease in a few days. In India again, the researches, more especially of Dr. M'Clellan, show very conclusively that it is found to prevail only where the magnesian limestone formation prevails. Whether lime and magnesian salts, or ferrum sulphide, as has been suggested by M. Saint-Lager, be the active agents in producing the disease has not yet been rendered quite clear; but it appears certain that goitre is originated by water-impurities, and that these are of an inorganic and not organic nature.

The latest authorities on the subject believe the impurity to be of a metallic nature, probably some salt of iron, and explain the prevalence of the disease in localities where the magnesian limestone formation prevails, by maintaining that metalliferous earths are always to be found in those districts. In support of this view it must be admitted that in many limestone localities

the disease is by no means prevalent, as, for example, in Scotland, Ireland, Norway, and Sweden, where mountain limestone enters largely into the geological formation. —(Quain's *Dictionary of Medicine.*)

The disease is far more prevalent among women than among men, and Dr. Thursfield, medical officer of health for the combined Shropshire Districts, has advanced the theory that it is caused in great measure by carrying weights on the head.

The effects of minute traces of metallic compounds in drinking water are as yet comparatively unknown. It is quite possible that the sanitary condition of a district may in some measure depend on impurities of this description, and, as Mr. Wanklyn suggests, that the salutary effect of "change of air" may be partly due to change in the minute metallic impurity in the water of the parts of the country which are visited.

Of the metallic ingredients, the effects of iron and lead have been the most fully ascertained. It would appear that iron, if present in quantities large enough to impart a chalybeate taste to the water, often produces headache, slight dyspepsia, and general *malaise*, while impregnation with lead from leaden cisterns or pipes has frequently been followed by symptoms of lead-poisoning. In the case of the ex-royal family of France, many of whom suffered when at Claremont from this species of water contamination, the amount did not exceed one grain per gallon; indeed, from cases which have since occurred, it seems probable that the habitual use of water containing from one-tenth to one-twentieth of a grain per gallon may be attended with danger. In his investigations with regard to the Devonshire colic, which formerly prevailed to a great extent, Sir George Baker found that eighteen bottles of cider which he examined contained $4\frac{1}{2}$ grains of lead, or a quarter of a grain to each bottle.

The impregnation arose from lead being employed in the construction of the cider troughs. With regard to the minor effects of lead-poisoning, there are good grounds for believing that many obscure forms of disease, partaking more particularly of the nature of dyspepsia and colic, are due to this cause.

Arsenic, copper, or mercury are only found in the drinking waters of this country in injurious quantities when streams are polluted by the washings from mines or chemical works.

Section II.—Water rendered impure by Vegetable Matter.

Vegetable matter may be present in water either in suspension or in solution. In peaty water, which is characterised by its brownish tint, the dissolved impurities sometimes do not exceed two grains per gallon. In the absence of a purer supply, a water of this description cannot be pronounced objectionable, provided that it is not stored in leaden cisterns, and that the supply is constant. If stored in open-air ponds or reservoirs it is improved by oxidation and light; and it is further improved by filtration through gravel and sand.

Water containing a considerable amount of vegetable matter, partly in suspension and partly in solution, is decidedly unwholesome. It has been known to produce violent outbreaks of diarrhœa, and, since the days of Hippocrates downwards, it has been popularly acknowledged to be productive of ague and other malarious ailments. In this country there are several instances on record that ague has been much lessened in small communities by using well instead of surface water; and there is strong presumptive evidence that, apart from the influences attaching to improved drainage, the great

decline of this disease throughout many parts of England, where it formerly prevailed, is in some measure due to the use of purer water.

Section III.—Water rendered impure by Animal Organic Matter.

From a sanitary point of view this is by far the most important class of water impurities. The presence of putrescent animal matter, whether it has percolated through the soil from cesspools or other filth-accumulations into wells, or whether it has been discharged from open sewers into streams and rivers, converts drinking water into a dangerous poison, fraught with disease and death. It is true that to a certain extent the process of filtration through a porous soil tends to render less hurtful the sewage which dribbles into a well, but after a time this purifying power is lost, the soil becomes sodden, and the sewage enters unchanged. It is also true that, given a sufficiently large stream, a sufficient length of course, and a sufficient length of time, the greater portion of the sewage discharged into a river will become converted into harmless products by oxidation. Yet neither process can be trusted, however complete it may appear to be. There is always danger lurking in a water which is known to be contaminated with animal matter, and more especially when such matter is partly composed of the evacuations of patients suffering from certain specific diseases, such as cholera or enteric fever. The germs of disease which may be communicated in this way have a tenacity of life or chemico-physical power altogether beyond our knowledge.

Leaving out of consideration the question whether animal organic matter in suspension or in solution is the more injurious to health, it would appear that it is the quality rather than the quantity which determines the

danger. As already stated, a trace of fæcal matter, especially when undergoing active chemical change, may render a public well poisonous, while a stream of sewer-gas may contaminate the contents of a cistern, and be the means of prostrating a whole household.

The principal diseases which have been proved to be produced by this class of water impurities are cholera, enteric fever, dysentery, and diarrhœa.

1. *Cholera.*—Although much had been previously written with regard to the etiology and spread of cholera, it was not generally surmised that the disease could be propagated by a polluted water-supply until the late Dr. Snow published the results of his researches in 1849. At first Dr. Snow's views were rejected by some, or questioned by others; but in 1854 there occurred a violent outbreak of cholera in the parish of St. James, Westminster, the causes of which were inquired into by a committee of medical men, whose report fully substantiated Dr. Snow's conclusions. Between the 31st August and the 8th September of that year as many as 486 fatal cases occurred within an area bounded by a circle whose radius scarcely exceeded 200 yards. On inquiring into the local peculiarities of the epidemic, Dr. Snow found that the sufferers had been in the habit of drinking the water supplied by a pump-well in Broad Street, which had a great reputation for freshness and sweetness. An analysis of the water proved that it was highly charged with animal impurities, and, at Dr. Snow's earnest solicitation, the handle of the pump was removed by order of the vestry on 8th September, to prevent further use of the water. After this the disease gradually subsided, and ultimately disappeared. It was made manifest, by a subsequent examination, that the sewage of a neighbouring house had leaked into the well, and it was further ascertained that the evacuations of a patient residing in

the house, and who was suffering from diarrhœa, or actual cholera, must have mingled with the sewage immediately before the occurrence of the general outbreak. No evidence could well be more convincing that, in this instance at least, the choleraic poison had been conveyed by the drinking water.

Amongst other remarkable outbreaks, which go to prove that this mode of cholera propagation is not at all uncommon, may be mentioned the following:—In the autumn of 1865 a gentleman and his wife, from the village of Theydon-Bois in Essex, had been lodging at Weymouth for two or three weeks, and returned home towards the end of September. On their way home they passed through Dorchester, where the gentleman was seized with diarrhœa, vomiting, and cramps, which continued more or less during the next day and the day following, when they reached Theydon-Bois. During the journey the wife also began to complain of abdominal pain, which was followed by diarrhœa and eventually by cholera, from which she died. A few days after their return the disease rapidly attacked other members of the household, so that, "within a fortnight, in that one little circle, eleven persons had been seized with cholera—mother, father, grandmother, two daughters, son, doctor, serving-lad, servant-maid, labourer, and country-woman; and of these eleven only three survived—the son, a daughter, and the serving-lad. Later, in the country-woman's family, there was another fatal case. It cannot well be doubted," continues Mr. Simon, "but that the exciting cause of this succession of events was, in some way or other, the return of the parents from Weymouth; of the father with the remains of choleraic diarrhœa still on him, of the mother with apparently the beginnings of the same complaint. But this is only part of the case, and the remainder teaches an impressive lesson. All

drinking water of the house came from a well beneath the floor of the scullery, and into that well there was habitual soakage from the water-closet."—(*Eighth Report of the Medical Officer of the Privy Council.*)

In addition to Mr. Simon's report on the cholera epidemics of London in 1848-49 and 1853-54, in which there is sufficient evidence to show that the prevalency of the disease in certain districts was almost entirely determined by the degree of impurity of the water-supply, the conclusions, more especially of Dr. Farr and Mr. Radcliffe, with regard to the localisation and distribution of the epidemic of 1866, are, if possible, more confirmatory still. Thus, Dr. Farr, in his evidence before the Royal Commission on Water Supply in 1869, stated that "in all the districts supplied by the Grand Junction, the West Middlesex, and the Chelsea Waterworks Companies, the mortality was about 3 in 10,000; in those supplied by the Southwark and Lambeth Companies, which were formerly so heavily visited, it was about 6 in 10,000; and in those supplied by the New River Company, about 8 in 10,000; while in those supplied by the East London Company, from the Old Ford Reservoirs, it was 79 in 10,000." In effect, the area of explosion was found to be limited to the district supplied by the East London Water Company, and not only so, but Mr. Radcliffe's investigations proved that the water delivered from the Old Ford covered reservoirs had been polluted with water from the filthy uncovered reservoirs, and that these latter had, in all probability, been contaminated with soakage from the river Lea, which received the evacuations of the first two patients who died of epidemic cholera in the eastern districts.

With regard to Scotland, the evidence of Dr. Stevenson Macadam, as to the influence of impure water on the spread of cholera, is also very conclusive. In a report

read before the members of the British Association in 1867, he showed very clearly that the ravages of the disease were coincident in time and place with the use of water from impure wells, and that in all cases the abatement of the outbreak followed the introduction of a pure and fresh supply.

Without quoting further evidence, it is sufficient to state that the weighty authority of Dr. Parkes strongly confirms this view of choleraic contagion; and indeed the opinions of Professor von Pettenkofer, though at first sight they appear to be antagonistic to the theory, do in reality support it. For, while he considers that the propagation of cholera is due to a fermentation of the rice-water stools, he also maintains that this ferment can only act, and the contagion be generated, under certain local conditions—namely, when there is a damp porous subsoil to receive the ejecta. Although Pettenkofer believes that the air is the sole channel by which the cholera miasm, thus generated in the soil, is spread, there is no doubt that the bearing of the geological influence amounts only to this,—that where populations are living on a damp open subsoil, with no artificial water-supply, nor any efficient system of drainage, there the drinking water, as well as the local atmosphere, is almost certain to be largely polluted by those fæcal impurities amid which the diarrhœal contagia are peculiarly apt to multiply.—(*Simon.*)

Whether cholera can be produced by animal organic matters not of a specific nature is still an open question. Very probably the effect of constantly drinking a certain amount of these impurities produces a lowered state of the system and a tendency to diarrhœa, so that, when the cholera poison is abroad in the atmosphere, it finds its victims in largest numbers amongst those who partake of an impure water-supply. This much, however, appears certain, that whenever cholera evacuations make their

way into the drinking water, we may expect to find the disease burst forth with the greatest virulence and fatality amongst those who use the water, and that indeed the endemic area will approximate with remarkable closeness to the limits of the district which it supplies.

2. *Enteric or Typhoid Fever.*—The remarks which have just been made with regard to the influence which impure water exerts on the spread of cholera apply with still greater force to the etiology of enteric fever. For, although there are still some who do not believe in the communicability of the disease, there is a constantly accumulating amount of evidence which goes to prove not only that the poison of the fever may be conveyed through the agency of water from the sick to the healthy, but that this is the most common mode of propagation. Sir W. Jenner, than whom no higher authority could well be quoted, in commenting on this point, says,—"The spread of typhoid fever is, if possible, less disputable than the spread of cholera by the same means. Solitary cases, outbreaks confined to single houses, to small villages, and to parts of large towns—cases isolated, it seems, from all sources of fallacy—and epidemics affecting the inhabitants of large though limited localities, have all united to support by their testimony the truth of the opinion that the admixture of a trace of fæcal matter, but especially the bowel excreta of typhoid fever, with the water supplied for drinking purposes, is the most efficient cause of the spread of the disease, and that the diffusion of the disease in any given locality is limited, or otherwise, and just in proportion as the dwellers of that locality derive their supply of drinking water from polluted sources."

According to the late Dr. William Budd it also appears to be highly probable that when the poison is conveyed by water, infection is much more certain than when it is disseminated by the air; and in support of this statement

he instances an outbreak which occurred in Cowbridge in Wales, in 1853, where, out of some 90 or 100 persons who went to a ball, fully one-third were shortly afterwards laid up with fever. Although the water was not examined, there was satisfactory reason to believe that it was polluted.

Since that date numerous other local outbreaks have been carefully investigated, and some with so much precision and completeness of detail that they are noticed here rather as examples of the painstaking and systematic way in which such inquiries should be conducted than as proving this mode of propagation of enteric fever :—

(1.) In the spring of 1867 Dr. Thorne, one of the Health Inspectors of the Privy Council, was ordered to proceed to Winterton in Lincolnshire, to inquire into the causes of the excessive mortality from enteric fever which had prevailed more or less during the previous two years in different parts of the town, but had latterly assumed alarming proportions. The small town numbered about 1800 inhabitants, of whom about nine-tenths consisted of the labouring classes, living for the most part in well-built cottages and earning good wages. Absolute poverty was little known amongst them, intemperance was rare, and only in two instances was there any overcrowding. Moreover, the situation of the town was healthy, inasmuch as it was built on a gentle slope facilitating drainage, and the subsoil was open and porous, consisting of a stratum of oolitic limestone covered by a light marly soil. Yet, with all these advantages, the number of deaths in 1865 amounted to 51, and in 1866 to 44, and of these more than a third had died of enteric fever. At the date of Dr. Thorne's visit 55 cases were under treatment, and already 6 deaths had occurred since the beginning of the year. The cause of all this sickness and mortality Dr. Thorne ascribed to the disgraceful state of the privies, ash-

pits, cesspools, and wells, the filth everywhere soaking into the ground and polluting the wells, and the discharges from patients thrown carelessly into ash-pits and thereby engendering specific pollution of both air and water. "Given," says Dr. Thorne, "the existence of typhoid fever in a town, it is hardly possible to conceive of conditions more favourable for its spread than those existing in Winterton."—(*Tenth Report of the Medical Officer of the Privy Council.*)

(2.) In the autumn of the same year (1867) a severe epidemic of enteric fever broke out in Guildford. Dr. Buchanan, who was the Government Inspector on this occasion, found that during the first twenty-eight days of August, 10 cases of the disease had occurred in different parts of the town; when suddenly, within the next thirty-three days, the number rose to about 250. As the epidemic was almost exclusively confined to a part of the town which corresponded with a particular section of the public water-supply, suspicions were aroused that this had become polluted; and on further investigation it was ascertained that on a particular day, about ten days before the outbreak, the houses in that part of the town had been *exceptionally* supplied with water from a certain high-standing reservoir which had previously been filled from a new well. This well was sunk through a porous stratum of chalk, and in close proximity to it were various sewers, one of which was afterwards found to be leaking in several places. There was no doubt, therefore, that sewage had oozed through the chalk into the well, and had caused the epidemic. An analysis of a sample of the water was subsequently made by the late Professor Miller, the results of which gave unmistakable evidence of previous sewage contamination.—(*Tenth Report of the Medical Officer of the Privy Council.*)

(3.) The account of the epidemic at Terling in Essex,

by Dr. Thorne, is especially valuable as showing the effect of a sudden rise of the ground water-level in a village situated on a porous subsoil, obtaining its water-supply from shallow wells, and allowing its excrementitious filth to accumulate in badly-constructed privies and manure heaps, or to lie indiscriminately in scattered masses on the surface of the ground. Out of a population of 900 about one-third of the number were attacked with enteric fever within a period of two months, and 41 had died. Some ten days before the outbreak, and after a period of prolonged drought, a sudden great rise in the water-level of the wells was observed to follow a heavy fall of rain and snow; in other words, the shallow unprotected wells sunk in the porous gravel had become converted into so many receptacles for the washings of the filth-sodden soil, and hence the epidemic.—(*Tenth Report of the Medical Officer of the Privy Council.*)

(4.) In the beginning of 1873 a severe outbreak of enteric fever occurred in the small town of Sherborne in Dorset, which was investigated by Dr. Blaxall, and which is of extreme interest as having been the first outbreak of the kind which was clearly traced to the entrance of sewer air into the water-mains. Although the water-supply was intended to be constant, it was ascertained that in December 1872 and January 1873 the water was frequently shut off at a point near the reservoir, and that during the month of February it was shut off every night. It was observed that when the water was turned off there were certain water-mains up which there was a sudden rush of air immediately the tap was unscrewed, and as many of the mains communicated directly with closet-pans by means of taps, which were sometimes left open, and which in other instances were broken, there were thus numerous inlets for the entrance of air from the closet-pans into the water-mains. Moreover, if a pan

happened to become full of excremental filth, there was the probability of excrement as well as sewer air having been sucked into the mains. In January and February there were about 27 cases of fever in the town, but before the end of April the number altogether had increased to 240, out of a population of 6041. After the first week, during which 73 cases occurred, the water-supply was again made constant, and the epidemic gradually declined. —(Mr. Simon's *Reports*, New Series, No. II.)

(5.) Somewhat akin to this outbreak in its mode of causation was the outbreak of enteric fever which occurred at Caius College, Cambridge, towards the close of 1873. Dr. Buchanan's report on this outbreak is such a model of painstaking research and sound reasoning that, apart altogether from its intrinsic value as a contribution to the etiology of fever, it ought to be read by every medical inquirer as one of the most lucid expositions in the domains of medical logic. Without detailing at any length the various interesting phases of the inquiry, it will be sufficient here to state that the cases of fever numbered 15, that the incidence of these cases was wholly upon the 112 students who were resident in the college, and that 12 out of the 15 cases were confined to 63 students, residing in a particular part of the college, namely, Tree Court. After considering all the more usual ways in which enteric fever is known to be spread, and finding that none of them could account for the intensity of the incidence of the outbreak in Tree Court, Dr. Buchanan's suspicions were directed to the water-supply. Now, the water-supply of the college was taken from a surrounding 5-inch main at six different places, and at one of them, namely at the Gate of Humility, there was a branch main which supplied Tree Court and no other part of the college. In short, the area of this particular water distribution was the area of

the fever, and although there was no doubt that the quality of the public water-supply was good, this was no argument against a "local contamination in a local service." It had struck Dr. Buchanan at an early stage of the inquiry that the closets in Tree Court were the only closets in the college which were not provided with cisterns, but were supplied with water direct from the high-pressure constant main; and on further inquiry the following facts were ascertained:—(1) That, according to the servants, there was occasional intermission in the constant service of water-supply; (2) that there had been two actual intermissions during the term, one of which occurred about 25th October, or a fortnight before the first case, and the other certainly on 1st November, a fortnight before the date of the second, third, and fourth attacks; and (3) that, although the mains were supplied with valve-taps which were believed to prevent any regurgitation of air or water, it was clearly proved by experiment that there was a reflux of air and water into the main when the water was turned off, and that the valve-tap was useless in this particular instance for the purpose for which it was intended. This view of local contamination of the water-supply was further substantiated by an analysis of the dirty-looking layer which was found to line the pipes, which showed that the layer consisted of a large proportion of nitrogenised organic matter and phosphoric acid, clearly showing that liquid filth as well as sewer gas had entered the pipes.—(Mr. Simon's *Reports*, New Series, No. II.)

(6.) While there can be little doubt that this particular mode of enteric fever propagation is much more frequent than is usually suspected, the following outbreak will suffice to show the dangers which threaten any town where closets directly connected with water-mains are numerous, and where the water-supply is intermittent:—

During the latter half of the year 1874 an epidemic of enteric fever prevailed in the town of Lewes, of such severity that out of a population of about 11,000 nearly 500 cases had occurred, and as many as 104 of these took place during the last week of October. Dr. Thorne, who was appointed to report upon this outbreak, discovered, after minute inquiry, that "it was due, in the first instance, to pollution of the town water-supply by water drawn from the Ouse, which receives the town sewage, but mainly spread by suction of polluting matter into the water-pipes of an intermittent water-service." So soon as it became clear that the epidemic was not only favoured but practically insured by the intermittent water-supply, Dr. Thorne urged the necessity of a constant service, and when this was obtained the epidemic became virtually arrested.—(Mr. Simon's *Reports,* New Series, No. IV.)

(7.) In the autumn of 1884 a very severe outbreak of enteric fever occurred in Kidderminster, which was carefully investigated by Dr. Parsons, one of the Local Government Inspectors. At the date of his visit, on 22d September, there were over 600 cases out of a population of 26,000, and before November they mounted up to 1200. Suspicions strongly attached to temporary pollution of one of the sources of water-supply, namely, a deep well which was situated within 94 feet of the sewage-tank and pumping station. Although at the date of the inquiry it was not possible to determine either by analysis or by inspection that leakage from the sewage-tank into the well had occurred, it was subsequently discovered that an old drain between the well and tank did exist, and there is no doubt that when the level of the water in the well was lowered during the dry season, pollution by this means did take place, and originated the outbreak. The spread of the disease after-

wards was largely fostered by the faulty condition of sewers and drains, intermittent water-service, and the abominable condition of midden-privies.—(*Special Report to Local Government Board.*)

(8.) Another outbreak which was investigated by Dr. Page on behalf of the Local Government Board towards the close of 1884 was also found to be associated with probable pollution of the public water-supply. The outbreak occurred in Beverley in Yorkshire, and careful inquiry showed that it was in all probability originated by percolation of sewage from a field contiguous to the water-works, which was used for irrigation purposes in connection with the East Riding Asylum.—(*Special Report to Local Government Board.*)

Although in these several epidemics there was no direct evidence to show that the outbreak depended, in the first instance, on the presence of the enteric poison in the sewage which contaminated the water, it is nevertheless noteworthy that cases of the fever were more or less common in the several localities previous to the outbreak, and as regards Beverley, it was found that two cases of enteric fever had occurred at the asylum before the disease broke out in the town. The following outbreaks, however, are strongly corroborative of the view which is maintained by many that the disease is essentially a specific disease, and can only be propagated by means of a specific contagium :—

(*a.*) In 1872 an outbreak occurred at Nunney, a village near Frome, and Dr. Ballard, the Local Government Inspector, who was sent to investigate the causes of the outbreak, thus states the conclusions deducible from his inquiry :—"(1) That the fever at Nunney was enteric ; (2) that it was brought into the village from a distant place by an individual whose evacuations, and those also of others attacked in the same and in the

adjoining house, found their way into the Nunney brook, at the upper part of the village; (3) that the fever spread in the village in consequence of the villagers habitually drinking the water of the brook thus contaminated, which water was still further polluted with the sewage of the village itself, containing, if not the actual excrement of the sick, yet certainly matters washed out of their soiled linen, and also more or less of their liquid evacuations; (4) that at the time of my visit actual excrement from cases of enteric fever was finding its way into the brook at a hamlet only half a mile above the village of Nunney." —(*Local Government Board Reports*, 1873.)

(*b.*) The outbreak at Over Darwen, which occurred towards the close of 1874, is alike remarkable for its terrible severity and for the thoroughness with which the cause of the outbreak was traced to its origin. According to Dr. Stevens, who was appointed by the Local Government Board to inquire into and report upon the epidemic, the first case occurred at a house some considerable distance from the town, but not very far distant from the public water-main. The patient, having contracted the disease elsewhere, afterwards came home ill, and died there. On first inquiry it was stated that the water-supply could not by any possibility be polluted by the excreta from this case, but subsequent investigations rendered it only too apparent that here lay the whole cause of the epidemic. It was discovered that the drain of the closet into which the excreta of this patient were thrown crossed the line of the water-main, and though special precautions had been taken by way of cementing and the like to prevent any leakage, it was found that the drain had become choked up, that the cement had given way, and that the contents of the drain were sucked freely, indeed regularly, into the water-main. No doubt the general filthy condition of the town greatly aided in pro-

pagating the epidemic after the specific contagium had been distributed by means of the water-supply, but the terrible rapidity with which the disease spread pointed clearly to specifically polluted water as being the prime cause of the epidemic. Out of a population of about 22,000, 2035 people were attacked within a very short period, and of those 104 died.—(*Local Government Board Reports*, 1875.)

(*c.*) In the small village of Lausen in Switzerland there occurred an outbreak of enteric fever in 1871 which proved that even filtration through a considerable tract of porous soil will not purify water which has once been specifically tainted. It was found, when the outbreak was investigated, that all the houses in the village, with the exception of six, were supplied with water by means of wooden pipes from a certain spring, and that the outbreak was confined to the inhabitants who drank this spring-water, the other inhabitants, who drank well-water, having entirely escaped. That the disease had been introduced by the spring-water was made clear by the following facts:—Behind the village there is a hill about 300 feet high, the westerly spur of which extends into a small side valley, and through this valley runs the Furler brook. Connected with this brook there were the latrines of several scattered farm-houses, in one of which four persons had suffered from enteric fever in the months of June and July. Although at first sight it did not seem possible that there could be any connection between these cases and the outbreak at Lausen, it was ascertained that when the meadows in the Furler valley were watered by damming up the brook, the spring increased in amount, and that when they were thus treated in July it yielded a turbid and bad-tasting water. Not long afterwards, namely on 7th August, 10 inhabitants were attacked, and in nine days more 57 persons were prostrated with the

disease, the number reaching to 130 at the end of October. To prove that the Furler brook could contaminate the spring at Lausen, the experiment was tried of putting common salt into the brook, when it was discovered that the spring water became quite briny.—(*Deutsch. Arch. für Klin. Med.*, 1873.)

(*d.*) In the early part of the year 1879 there occurred a severe outbreak of enteric fever at Caterham and Redhill in Surrey, in which within a period of about six weeks there were about 370 cases and 21 deaths. The outbreak was investigated by Dr. Thorne, and his report, apart from its painstaking nature, is of special interest, inasmuch as the disease was brought about under conditions which stand alone in the history of such epidemics. Briefly, it was discovered on careful inquiry that the outbreak was traceable to the circumstance that one of the workmen employed about a fortnight previously in driving an adit leading from an old well to a new bore at the Caterham water-works had been suffering from diarrhœa and typhoid symptoms, and that for several days the diarrhœa was so severe that he was compelled to evacuate in the adit. On the completion of the work the water thus became specifically polluted, and the distribution of the disease was found to be limited to houses supplied by the Caterham Company.

(*e.*) During the summer and autumn of 1882 a very extensive outbreak of enteric fever prevailed in Bangor and the immediate neighbourhood, which forms the subject of a special report by Dr. Barry, one of the Local Government Board Inspectors. The initial cause of the outbreak, as previously traced by Mr. Rees, the Medical Officer of Health for the Carnarvon Combined Districts, was found to be due to specific pollution of the public water-supply, which is obtained from a small stream called the Afon Gaseg. It appeared that towards the end of

May a case of illness, which was subsequently confirmed to be enteric fever, occurred in a detached house at Llwynrhandir, and the drain from this house discharged into a small rapid stream, which in its turn discharged into the Gaseg at a point about 350 yards above the intake of the Bangor water-supply, the whole distance from the house to the intake being about 700 yards. The incidence and simultaneous appearance of the disease in various districts and streets at once suggested some common medium of infection, and all the facts pointed clearly to a tainted water-supply. The main points connected with the outbreak are summarised by Dr. Barry as follows:—

"(1) That the original case at Llwynrhandir, which began on the 22d May, had probably been passing infected matter into the Gaseg, to a greater or less extent, from that date until 30th June.

"(2) That prior to 26th June two further cases had occurred in the same house, and that in these, owing to the mildness of the disease, no precautions had been taken, and the danger of infected matter passing into the stream had been thereby much increased.

"(3) That, owing to the flushing and consequent bursting of the water-main, considerable disturbance occurred in the water-supply on 30th June and 1st July.

"(4) Finally, that a simultaneous outbreak in various new localities occurred from ten days to a fortnight after this took place."

The first period of the outbreak, which extended from the last week in May to the end of the first week in July, was characterised by a continued series of drooping cases occurring simultaneously in different parts of the town and district. During this period there was every reason to believe that a considerable amount of the infected material was retained in the very imperfect filtering beds,

and when these were disturbed after the bursting of the water-main the water became impregnated to a much more dangerous extent, and hence the sudden outbreak which characterised the second period. After a time the sewers became seriously infected, and no doubt the disease was subsequently spread in this way, though the tardy action of the sanitary authority in cutting off the source of pollution and removing the filtering material contributed to swell the alarming dimensions of the outbreak. Altogether the number of cases amounted to 540, out of a population of about 10,000 in the town and infected neighbourhood, and of these 42 had proved fatal up to 12th September. In stamping out the outbreak, it may be added that tents were largely used for isolating the patients.—(*Special Report to Local Government Board.*)

The following outbreak merits particular notice on account of its unique character, and as being the first of the kind reported. During the course of the first week in August 1882 Mr. George Fosbroke, medical officer of health for the Combined Stratford-on-Avon Districts, was called upon to investigate an outbreak of enteric fever which had suddenly assumed unusually extended proportions in the town of Evesham and the adjoining neighbourhood. Before the close of September as many as forty-eight cases had occurred in the borough, and twenty-one in the rural districts, five of the former and three of the latter having proved fatal. The suddenness of the outbreak, widely scattered though many of the cases were, pointed to some common cause; and, after careful inquiry, Mr. Fosbroke discovered that all the patients first attacked had attended a regatta held at Evesham on 12th July, and further, that they had all frequented a particular meadow adjoining the river Avon. Still more extended inquiry disclosed the fact that all these persons had partaken of "spirits, lemonade, or ices" while on the

meadow, and that the water used either for diluting the spirits or manufacturing the lemonade and ices was obtained from a well which was subsequently found to be contaminated with sewage; but whether specifically contaminated was not quite clear, although suspicions strongly pointed in that direction. In any case, there is no doubt that the water from this well used for the manufacture of the lemonade was the cause of the outbreak, and subsequently, by direct or indirect means, affected no less than 113 persons.—(Mr. Fosbroke's *Report* for 1882.)

But in country districts there occur many scattered cases of enteric fever, which, although they have a water origin, cannot be traced to specifically polluted water. According to my own experience, and it accords with that of many other health officers who have studied the etiology of enteric fever in rural districts, the disease is frequently produced by drinking water which is found to be polluted with animal matter, but not with specifically tainted matter. As regards these cases, the most careful inquiry has failed to discover any connecting link between them and pre-existing cases, while in all of them it has been found that the well-water has been polluted by leakage from some cesspool, privy, or drain. It may be said, therefore, that, though they are essentially pythogenic, they are not specific. All this, however, will be discussed more fully in a subsequent chapter (see Chap. XIV.)

3. *Diphtheria.*—Although the etiology of this disease, especially as regards several recent outbreaks, has been by no means clearly established, there are grounds for believing that it is frequently associated with polluted water. Certainly, the majority of the sporadic cases which have come under my own notice have occurred at houses where polluted well-water was the only cause which could be discovered, and from the answers sent in reply to the circular issued in 1878 by the Society of Arts with refer-

ence to our National Water Supply, it appears that there are a good many other medical officers of health who hold similar views. In an outbreak at Kirkella in Yorkshire, which was investigated on behalf of the Local Government Board by Dr. Blaxall, there was reason to believe that the water-supply of the school had been implicated in the causation of the disease, while other outbreaks have been instanced having a similar probable origin.

4. *Dysentery.*—The instances of outbreaks of this disease which have been traced to the presence of animal impurities in drinking water are so numerous, especially in Eastern countries, that the mere mention of the fact will suffice.

5. *Diarrhœa.*—In addition to outbreaks occasioned by direct sewage contamination, there are several recorded cases of the following description:—In the Salford Jail there was a sudden outbreak of diarrhœa of a choleraic type, which affected 57 per cent of the prisoners, while of the officers and their families, who were distributed throughout the building, not one was attacked. The food of the prisoners was examined and found to be good; it was evident also that the air did not contain the cause of the disease, for both classes were under the same conditions in that respect; suspicion was therefore directed to the drinking water. It was then discovered that, though the water supplying all parts of the prison was derived from the same source, there was one cistern for the use of the officers, and another covered cistern to supply the prisoners, and that the untrapped overflow-pipe of the latter communicated with an open sewer. On the day of the outbreak the water from this cistern was observed to be coloured, and to taste unpleasantly. It had obviously absorbed sewer-gas, which had ascended through the overflow-pipe; and that this had been the real cause of the disease was confirmed by the fact that the outbreak dis-

appeared almost as rapidly as it commenced, when the cistern was emptied and the pipe efficiently trapped.—(*Second Report of the Medical Officer of the Privy Council.*)

According to my own experience, much of the diarrhœa which prevails in country districts during the summer and autumn amongst children is due to polluted water drunk either as it is drawn from the well or when mixed with milk.

Concluding Remarks.—Although an attempt has thus been made to classify roughly the hurtful impurities of water, and the diseases which they may severally produce, it need hardly be said that in the great majority of instances of faulty sanitation connected with water-supply, there is often a combination of impurities and of diseases both. For example, the analysis of waters which have proved to be decidedly injurious shows that in general the impurities are numerous; and, on the other hand, not one but several diseases may be either directly produced or indirectly influenced by them. And this difficulty of apportioning to special impurities their special effects is frequently increased by the presence of other causes of disease. Thus, the water may not only be polluted, but the supply may be scanty; and thereby give rise to great want of cleanliness of the person, of clothes, of cooking utensils, and of the general surroundings; while overcrowding, defective sewage-removal, badly ventilated drains, and other causes of disease, may also co-operate in seriously affecting the health of a community and largely increasing the death-rate.

Amongst other diseases which have frequently a water origin may be mentioned ulcerated sore throat, low fever, and erysipelas. Indeed, in purely country districts what is known as low fever is essentially a filth fever, and is found to be produced in the great majority of instances by polluted well-water.

It would also appear that the prevalence of calculous disease and gravel bears some relation to the amount of lime and magnesian salts contained in the drinking-water of certain parts of the country. This disputed subject has been carefully investigated by Dr. Murray of Newcastle-upon-Tyne (*Brit. Med. Journal*, 1872); and his statements, together with the cases which he adduces, are strongly corroborative of this view, but general statistical evidence is wanting.

Finally, it has to be noted that several of the entozoa find their way into the body through the agency of drinking-water, as, for instance, the *Bothriocephalus latus* and the *Ascaris lumbricoides*. The latter, which is known as the *round* worm, I have found to be common in districts where the water-supply is chiefly obtained from shallow dip wells.

CHAPTER IX.

DWELLINGS

THE vast importance attaching to the sanitary conditions of dwellings has already been frequently alluded to in previous chapters. Diseases arising from unhealthy site, from insufficient ventilation or overcrowding, from tainted or stinted water-supply, from defective drainage, or from accumulations of filth, are all of them associated with habitations which are faulty in their situation, construction, or management.

SECTION I.—SITE.

In choosing a site, special attention should be paid to the nature of the soil and the general conformation of the ground. Soils in order of healthiness may be approximately classed as follows :—Those overlying the primitive rocks, clay slate, millstone grit and oolite, gravel and loose sands, chalk, sandstone, limestone, and clays. The soil, if not dry, should be drained, and all hollows wherein water is likely to lodge should be avoided. For these and other reasons, the best situation for a house is on rising ground, with trees in the immediate neighbourhood, but not so close as to interfere with the free movement of the surrounding air. The aspect will very likely be influenced in great measure by the view to be obtained from the front windows, but it is preferable that a house should

face east or south-east, because in the morning the rays of the sun penetrate to the front rooms, and in the afternoon they cheer those at the back. When, on the other hand, a house faces south, the front rooms are overheated in summer by the rays of the noontide sun, while those at the back are deprived altogether of sunlight. Further, it is very essential in country districts that it be first ascertained that a good supply of wholesome water is procurable, and that there are no difficulties in respect to efficient drainage. If the subsoil is at all damp, it should be drained by suitable earthenware field-pipes, but care should be taken not to connect with house-drains unless under strict precautions as to disconnection and ventilation.

In towns, a great evil sometimes arises from building on rubbish containing vegetable matter which has been used to fill up the excavations made in brickmaking. Thus, in 1872, Mr. Crossby reported that the high rate of mortality in Leicester during the autumnal months was chiefly due to an annual visitation of infantile diarrhœa which prevailed in parts of the town built on such refuse; and he distinctly attributed the disease to this cause. It is also worthy of special notice that this opinion has since been fully corroborated by the very elaborate and painstaking report presented by Dr. Buck and Mr. Franklin on the epidemic of diarrhœa which prevailed in that town during the summer and autumn of 1875. Further, the evidence of Drs. Parkes and Sanderson, in their valuable report on the sanitary condition of Liverpool, though negative as regards the effects of cinder-refuse on the health of the occupants of houses built upon it, clearly points to the conclusion that such a soil is objectionable, at any rate when first laid down. With regard to this point they advised the Town-Council to adopt the following rules:—

"1. No excavation should be used for the reception of cinder-refuse unless it is efficiently drained. This appears to us to be of especial importance in relation to the filling up of brickfields. It is well known that the whole of the surface of clay is never removed, and there is always sufficient to form an impermeable basin, in which, in the absence of drainage, water constantly collects. We hold it to be of the greatest importance for the rapid decomposition of whatever offensive material may exist in the 'cinder,' that it should be able to become dry. The only way in which this can be promoted or secured is by efficient subsoil drainage.

"2. As the vegetable and animal matter contained in the cinder-refuse decays and disappears in about three years, and is virtually innocuous before that time, we recommend that places filled up with cinder-refuse shall not be built upon for at least two years from the date of last deposit."

They also advised that road-scrapings should not be mixed with the cinder-refuse, and that the scavenging department should be more careful with regard to the selection of material.

It need hardly be said that wells sunk in made-up soils of this description can only yield a water which is highly polluted and altogether unfit for use.

Section II.—Structural Arrangements.

In building on a site which has already been occupied great care should be taken to make a thorough examination of the ground, so that no cesspits, rubble drains, or old wells may escape notice. Every old drain should be taken up, all removable filth cleared away, and every pit thoroughly cleaned out and filled in with concrete.

Unless absolutely necessary, no drain should traverse the basement of a house; and when it is necessary, as when houses are joined together in streets or squares, every such drain should be made absolutely air and water tight. Pipes of glazed earthenware are best suited for the purpose, and should not be less than four inches in diameter. They should be laid on a bed of concrete made with ground lime or cement, securely jointed, and covered with concrete. They should also be provided with full means of ventilation and inspection at either side of the basement. When they pass through foundation walls it is advisable that relieving arches should be turned over them, because it often happens that they become broken by settlements, or during the consequent underpinning. Outside the building the pipes should be laid in a water-tight trench of clay puddle or concrete, and should lie their full diameters below the subsoil of the basement, in order that the lowest parts of the house may be efficiently drained.

According to the new model by-laws of the Local Government Board, provision should be made for at least two untrapped openings to the house-drains, so as to ensure the constant flow of a current of fresh air through them. One such opening should communicate with the drains by means of a suitable pipe, shaft, or disconnecting chamber, and be situated as near as may be practicable to the trap, which should be provided between the main drain and the sewer. This trap is generally a syphon-trap, and the ventilating opening, whether pipe, shaft, or simple chamber, should be situated on that side of the trap which is nearer the building. The second opening is to be provided by a vertical pipe or shaft, at least four inches in diameter, situated as far distant from the other opening as possible —that is, at the upper extremity of the drain—and carried to a height of at least ten feet, but so as to avoid the risk of discharging any sewer air into any window of the house

or adjoining building. When the soil-pipe enters the drain at the farther end, it will fully answer the purpose of this second ventilator, as shown at B in Fig. 5. Instead of the open grating at A, a ventilating pipe or shaft may

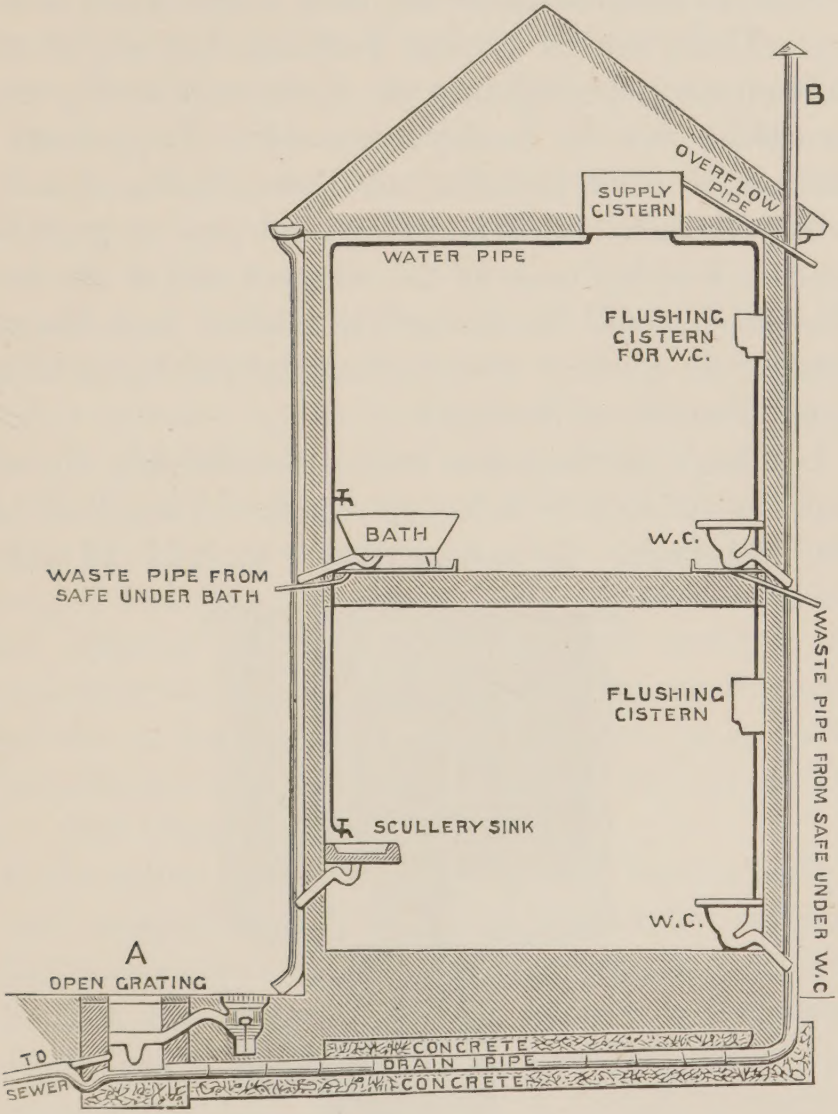

Fig. 5. (After Rogers Field, M. Inst. C.E.)

be provided, as when houses abut on a street, but in either case facilities are thus afforded for the passage of a constant current of fresh air through the entire length of house-drain, and the entrance of sewer air into the house

is rendered practically impossible. Fig. 5 also shows the arrangements for overflow from cistern, and disconnection of pipes from sink and bath.

To facilitate inspection, the outside track should be provided, at suitable intervals, with access pipes or man-holes. These are of various patterns, but all of them permit an easy opening into the drain, so that deposits or obstructions can be readily removed. To prevent the formation of such deposits, all house-drains should be regularly flushed, and it is a very good plan to provide an automatic flushing tank at the extreme end of the house-drain, which could be charged with slops from the sink, or water from a bath. (For further particulars, see Chapter XI., on Removal of Sewage.)

Doulton's patent grease interceptor (see Fig. 6), which is intended to receive sink-slops, makes an excellent automatic flush-tank. It is constructed to hold 12 gallons,

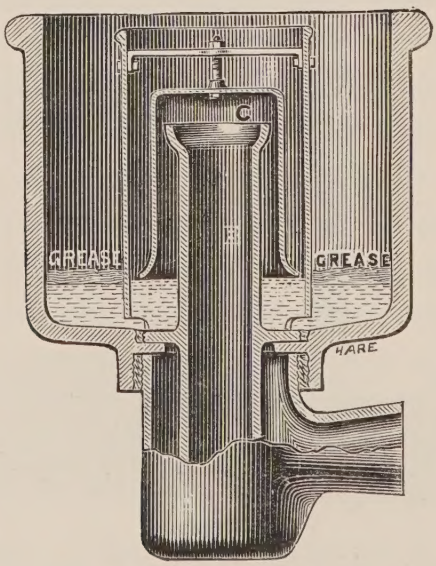

Fig. 6.

is 1 foot 6 inches in diameter and 1 foot 6 inches high, and comparatively cheap.

Where a cesspool is required to receive the sewage of a country house provided with water-closets, it should be

situated at a safe distance from the building, made perfectly water-tight, and be abundantly ventilated. It is also of the utmost importance that a syphon-trap and ventilator should be provided in the course of the drain and near the house. The plan of construction should be on the liquid-manure tank principle, the walls being of brickwork set in cement, surrounded by a clay puddle, and lined inside with a coating of cement. Both roof and bottom should be arched, the roof provided with a manhole, and the bottom built with a fall towards one end, where a pump could be fixed. The depth should not exceed 6 or 7 feet, otherwise the increased hydrostatic pressure would necessitate expensive walling. To separate the solids from the liquids a galvanised iron wire diaphragm or grating should divide the tank into two parts. All cesspools should be regularly and frequently cleaned out, and it is of the utmost importance that the drains should be trapped and disconnected, and the soil-pipe ventilated. If the cesspool is situated in a field or orchard some distance from the house, the liquid contents can frequently be got rid of by constructing an overflow-pipe leading into sub-irrigation drains, either with or without a flush-tank. (See Chapter XI.)

If the water-supply is to be derived from a well, the well and cesspool should be widely separated. In case of accidental leakage it is also necessary that the well should not be near the house-drains. To exclude subsoil water, the upper part of a well should be clay-puddled, or made otherwise water-tight, and the mouth should be protected against the entrance of surface-water. Every well should be ventilated and provided with a manhole for purposes of inspection and cleansing.

After having secured dryness and healthiness of subsoil, the next point of importance which has to be kept in view is the isolation of the area upon which the proposed

dwelling is to be erected from the subsoil, and this can be effected in the cheapest and best way by using concrete. In order to prevent damp from rising into the walls, a damp-proof course should overlay the whole of the foundations. Two or three courses of slate laid in the best cement will answer the purpose, or, if external symmetry in the damp-proof course be made a desideratum, tiles made of highly vitrified stoneware should be employed. When there is a basement story, it should be isolated from the ground by an open space. The entrance of underground damp may also be prevented by constructing what are called dry areas; that is, by leaving a space between the main wall and a thin outer wall, which reaches to the ground level, the two being joined together here and there by stretching bricks.

As much of the dampness in walls is due to driving wet, well-planned houses are now often built with hollow walls, in which case ties or bonding bricks must be laid in at regular intervals, to render the strength and stability of the twin walls equivalent to a strong single wall. With single walls, built of soft porous material, the effects of driving wet may be obviated by slating or tiling them, or by applying to the outer surface one or other of the several patent waterproof compositions which are well recommended.

Perforated bricks should be introduced at suitable distances in the outward walls, to admit air to the joists and beneath the flooring.

One of the gravest faults in the construction of even the better class of houses in the present day is the little attention which is paid to the position and arrangements of water-closets. They are too frequently situated in out-of-the-way corners, where only borrowed light can be obtained, and efficient ventilation is impossible. The best position is in an isolated block, built tower fashion, and

abutting against the outer wall of the house, with a closet on each floor and the supply cistern on the top. There should be an anteroom or passage between each closet and the house, large enough to admit of sufficient cross ventilation by means of open windows, or windows provided with ventilating panes. A double set of doors would be required,—one leading into the house and the other cutting off the passage from the closet. The closet-seat should face a window in the outer wall, so that abundance of light may be secured for inspection with regard to cleanliness, and direct draught from the window be avoided. The window should extend up to the ceiling, and have double sashes. The closet may be permanently ventilated by keeping the top sash drawn down, or by air-bricks inserted immediately beneath the ceiling. In smaller-sized houses the closet may be simply projected from the building, with the seat facing the door, and with two opposite windows reaching to the ceiling between the seat and door. Cross ventilation and sufficient light would thus be obtained, without the interposition of an anteroom. All, however, that is insisted on in the model by-laws of the Local Government Board is, that the closet should be built against an outside wall, and be properly lighted and ventilated.

There are so many kinds of closets, well arranged in all their details, that it is difficult to say which of them are most to be recommended. There are others, again, such as the round hopper closet-pan, fixed into an ordinary sigmoidal bend, which cannot be sufficiently condemned, unless worked by a very high pressure of water; they are constantly getting foul, and it is seldom that the whole of the excreta are removed; indeed, they can seldom be kept clean unless they are regularly flushed by a bucket or pail. Generally speaking, those closets are the best which provide for good flushing and rapid and complete

removal of the excreta, without permitting reflux of foul air. Every closet, unless it be flushed by hand, should be provided with a cistern, preferably of the waste-preventing kind, because it is of the utmost importance that there should be no direct communication with the water-main. Syphon waste-preventing cisterns are to be specially commended, and to secure a good flush the service-pipe should be $1\frac{1}{4}$ inch in diameter. It has also to be pointed out that the closet should not be supplied from the same cistern which supplies the drinking water. The pan should be roomy and made of glazed earthenware; the machinery should work easily and not be apt to get out of gear; and the seat should be so framed as to come asunder readily to permit of inspection. A very good arrangement is to have the seat hinged, and to have underneath a glazed earthenware tray overlapping the pan for the reception of slops. No closets should be constructed with either a "container" or a "D-trap," because both retain filth, and thus become a source of danger. Amongst closets which have been highly commended may be mentioned "Doulton's Closet;" Banner's Closet; Winn's Closet; Dodd's Closet; Bean's Household Closet; and Twyford's National Closet. For cleanliness and efficiency flush-out closets, such as Twyford's and Doulton's, are to be preferred.

As soil-pipes communicate directly with the drains, they should be carried up to the highest part of the roof, and be of the same diameter throughout. Efficient ventilation of the drains is in this way secured at a most important point, and the pipe from the closet trap can be connected with the soil-pipe without interfering with the upward current of sewer-air. If the soil-pipe cannot be carried straight up to the top of the house, the bends or angles should be made as obtuse as possible, and in any case it should not be plastered or built into the wall, but

left free for inspection throughout its whole track. It is obvious that, were this plan universally adopted, there could be no pressure of sewer-gas against the closet trap, and therefore little or no risk of its entering into the house by this channel. The waste-pipe from a housemaid's sink, intended to carry off foul matter, should be constructed and ventilated like a soil-pipe. Soil-pipes should be made of iron pipes, 4 inches in diameter, and specially coated.

With regard to all other pipes, whether waste-water pipes, sink-pipes, or pipes from lavatories, it should be laid down as a rule that none of them should lead directly into any soil-pipe or drain. They should be carried outside an external wall, and discharge in the open air over a channel leading to a trapped gully grating at least 18 inches distant. (See Fig. 5.) But although the sewer-gases are in this way prevented from entering the house, it is still necessary that the sink and other pipes should be trapped. Scullery and sink pipes, for example, will require article-intercepting traps, and pipes to lavatories or baths should be provided with syphon-traps to prevent the ingress of cold air. (See Fig. 5.)

All traps on house-drains should be ventilated either by pipes carried to the roof or parapet of the house, or by what is called direct ventilation. Unless protected in some such way they are comparatively useless. (See Chap. XI.) When a water-closet is dispensed with, some form of dry or pail closet, situated outside and at a safe distance from the well (if any), should be provided.

Details concerning the ventilation and warming of a house have already been given in Chapter IV., and the only points which need be repeated are—the importance of constructing a separate extraction-flue for each room in the chimney-stalk, the desirability of inserting ventilating fire-places, and the great advantage of securing that

the products of gas-combustion be conveyed by special channels into the outer air.

It is needless to say that the rooms in a well-constructed and healthy house should be spacious, airy, and light. The windows should reach to within a short distance of the ceiling, and should always be made to open. It is preferable to have them glazed with plate-glass, to economise heat. No single bedroom should be of less dimensions than 1000 cubic feet, nor should any bedstead be fixed in a recess.

Section III.—Dwellings for the Poorer Classes.

In constructing buildings for the poorer classes the great difficulty, encountered at the very outset, consists in providing the necessary accommodation with the requisite sanitary arrangements at a cost which will allow of a sufficiently low rental. In towns the original cost is greatly increased by the high price of land; but even in country places, where a site can be procured at a cheap rate, the cost for the erection of a cottage of the humblest pretensions will entail a rental which many a labouring man can barely meet. Where the ground-rental is low, the cheapest and most commodious form of labourer's cottage is one without any upper story. Thus, according to Mr. Allen, in his manual on Cottage Building, a cottage consisting of a living-room for general everyday use, a bedroom for the labourer and his wife, a bedroom for boys, a bedroom for girls, a small wash-house, a storeroom and closet, could be built for £100, provided all the rooms are on the ground-floor, and that two such cottages be ranged side by side, so as to be spanned by the same roof, and contained within four walls, forming a simple parallelogram.

In a paper read before the Farmers' Club in 1874, Mr. Howard of Bedford states that, some few years pre-

viously, he built a block of six cottages for his labourers entirely of concrete. The walls were a foot thick, and in consequence of the impervious nature of the material they were warmer and drier than ordinary brickwork. Each cottage contained three bedrooms, and each was provided with an earth-closet at the end, but accessible from within. Exclusive of the closets, the cost of the whole block was a little over £600, or £100 per cottage.

According to the design by Mr. Birch, which obtained the award of the Society of Arts in 1864 for premiums offered by Mr. Bailey Denton, the estimated cost of a pair of cottages was £203, including every requisite necessary to render them complete and fit for occupation. On the ground-floor it was proposed that there should be a living-room 12 feet 6 in. by 12 feet; a scullery, containing a copper for washing and a sink, 10 feet 5 in. by 7 feet 6 in.; and a small pantry and place for fuel opening into the scullery. On the chamber floor there were to be three bedrooms with a floor-space respectively of 12 feet 8 in. by 8 feet 6 in.; 7 feet 8 in. by 8 feet 6 in.; and 9 feet by 8 feet.—(See *Builder*, 1864.)

Owing to the increased cost of materials and the rise in wages, it is very likely that the above estimates would be found to be somewhat too low for the erection of similar cottages in the present day, but if built in blocks or pairs, I am credibly informed that good cottages with three bedrooms can still be erected for about £100.

In these plans, and in fact in almost all plans for cottage construction, the cubic space allowance is very limited, so that overcrowding, to a greater or less extent, is sure to prevail at times. Cottages which are scarcely roomy enough for a married couple and two or three children become occupied by much larger families, or the family increases in number year after year, while the bedroom accommodation remains the same. The initial space,

therefore, should be ample enough to meet the requirements of, at any rate, moderate family increase; and when a number of such cottages are built in the same locality, they should be of different sizes, to suit small and large families alike. The kind of closet best suited for country cottages is some modification of the dry system, while the slops, if they do not discharge into village drains, should be utilised in the garden, or disposed of by subsoil irrigation where that is possible. All this, however, will be discussed more fully in Chapter XI.

In large towns the house accommodation for the labouring classes must necessarily be supplied in a great measure by what are called tenements, but in this case special attention should be paid to sanitary arrangements, such as closet accommodation, water-supply, ventilation, and general cleanliness of premises, and a copy of rules or by-laws should be prepared and handed to each occupant.

Of equal importance with the construction of dwellings for the labouring classes is the far more difficult problem of repairing and improving the unhealthy abodes which, in town and country village alike, increase the annual rate of mortality to an extent that can hardly be estimated. It is true that the law already prohibits the inhabitation of the worst class of dwellings, such as damp, dark, underground cellars; but there are other dwellings, so numerous that their immediate demolition would deprive a large proportion of the lower classes of shelter, which no alterations or improvements can render healthy. They are either situated in narrow, dingy alleys, or huddled together in close courts, so as to be practically unventilable, or their internal condition and constructural faults are so grave as to be beyond remedy. Nor are these the only sanitary defects connected with them which have to be condemned. It is in these very dwellings that the filth and poisonous effluvia due to overcrowding are con-

stantly accumulating, and where the germs of disease find a fitting soil for their development. The departmental reports of the Privy Council afford numerous instances of such a state of things, and notably those of Drs. Hunter, Stevens, and Buchanan.

It is to be hoped that the carrying out of the provisions of the Artisans' Dwellings Acts, and of the Housing of the Working Classes Act, 1885, will soon effect a marked improvement in this respect in many of our cities and large towns, for hitherto the difficulty of dealing with what is called "surface-crowding" has thrown great obstacles in the way of reaping to the full extent the advantages to be gained from lessening the indoor overcrowding. In the worst parts of Liverpool, according to Drs. Parkes and Sanderson, nearly 1000 persons were huddled together in one acre of ground, and in other towns, such as Glasgow and Greenock, the number per acre in some districts is quite as great. It is clear, therefore, that no improvement in the dwellings, nor any increase in the amount of cubic space per head, will render the ventilation as satisfactory as it should be, when so many houses are packed together in such a limited space. Demolition of old houses, the displacement of the population into blocks of model dwellings, or into houses put into serviceable repair, and the opening of new streets, are all necessary.

As instances of successful enterprise in this direction, it may be mentioned that the London Improved Industrial Dwellings Company now provides house-accommodation for over 20,000 persons, and that during 1881 the death-rate averaged only 16·4 per 1000; while the Peabody Trust has provided accommodation for about 12,000 persons, and during the same year the death-rate averaged 17·2 per 1000 as against 21·2 for London generally.

In country districts, where there is far less excuse for the existence of these evils, it has been found that in reality they are almost as glaring and widespread as in towns. Unfortunately, too, many of these evils threaten to become perpetuated, inasmuch as rural sanitary authorities, unless they apply specially for urban powers, have no control over the erection of new buildings. Similar by-laws should be in force with respect to thickness of walls, height of rooms, ventilation, drainage, and general sanitary arrangements which are carried out in urban districts. Indeed, it is difficult to conceive why such control should not have been conceded to sanitary authorities without distinction, unless it be that sanitary legislation has hitherto been halting and one-sided. It is quite true that many sanitary defects connected with existing cottages can be dealt with under the wide term *nuisance*, such as—the repair of uneven floors, and roofs that let in the rain; the repair of dilapidated walls; the opening of closed windows; the removal of privies and pig-styes which abut against outside walls; the drying of the subsoil; the repair of drains; and the like. It is likewise true that if a house cannot be put into fairly habitable repair the law gives power to close it; but where houses are scarce, it need hardly be said that this becomes a very serious matter, inasmuch as it either tends to increase the overcrowding elsewhere, or leads to displacement of labourers and their families, an alternative which is attended at all times with much inconvenience, and very frequently with great hardship.

In large towns this displacement of the population becomes a question which naturally affects the poorer classes to a much greater extent than in country villages. Many extensive undertakings, such as the construction of railways and new streets, while they act beneficially in

making wide clearances in the crowded districts, almost of necessity conduce to overcrowding in neighbouring parts. The families that are thus rendered homeless by the demolition of their dwellings seek the nearest shelter, rents are raised in consequence of the increased demand for accommodation, and such as cannot afford to expend more than they did previously must be contented with homes even less healthy than those which they have been compelled to leave. As a compensating measure, the running of working men's trains morning and evening, between the suburbs and the town stations, although it is a step in the right direction, does not by any means meet the difficulty. Larger measures are undoubtedly required, and the more thoughtful amongst sanitary reformers are agreed in maintaining that no parlimentary powers, permitting the demolition of numerous dwellings in populous districts, should be granted unless the companies or corporations applying for these powers provide commensurate and improved accommodation elsewhere, and within reasonable distances. It is true that many of the displaced population might not choose to remove to the new dwellings, but they should have the option. Tenants, at all events, would not be wanting, and that there would be no financial loss is clearly proved by the profits gained by private enterprise in building homes for the working-classes, although it must be admitted that numbers of such houses, as they are run up in the present day, can scarcely be pronounced habitable. Urban sanitary authorities have, however, full powers vested in them by the statutes to prevent the erection of dwellings that are unwholesome, and it is their duty to see that the accommodation and structural arrangements are in all cases satisfactory.

Concerning the duties of the medical officer of health with regard to overcrowding and places unfit for habita-

tion, together with the sanitary enactments dealing with the same, see Chapter XVIII.

Section IV.—Sanitary Inspection of Dwellings.

1. *Diseases traceable to Sanitary Defects.*—There are so many diseases, and some of them so fatal, associated with sanitary defects in or around dwellings, that it is of the utmost importance that every medical practitioner, and above all every sanitary official, should be able to detect these hidden dangers, or direct how they may be discovered and remedied. Exclusive of new houses, which have been erected in accordance with well-devised by-laws, it is no exaggeration to say that in the vast majority of houses, and especially good-class houses, sanitary defects may be found which at any time may lead to the gravest consequences, and when disease does break out the wonder often is that the inmates should have escaped so long. Minor disorders, such as languor, headache, so-called bilious attacks, dyspepsia, diarrhœa, and slight ulcerated sore throat, are frequently allowed to pass unheeded, or are treated as ordinary ailments; and it is not till disease of more pronounced severity occurs that the sanitary condition of the house becomes suspected, and the real cause is discovered.

Apart from ailments which are connected with dampness of site, foundations, or of walls, such as rheumatism, phthisis, bronchitis, or other lung affections, the class of diseases which are associated with faulty house sanitation are essentially filth diseases, whether they originate *de novo* or are conveyed by befouled air or water. And among these diseases may be enumerated the following:—diphtheria, ulcerated sore throat, follicular tonsillitis, follicular stomatitis, croup, enteric and ill-defined forms of fever, diarrhœa and dysentery, erysipelas, carbuncle,

abscess, pyæmia, hospital gangrene, and puerperal fever. There is no doubt, too, that the breathing of vitiated air, whether depending upon overcrowding, defective ventilation, or the entrance of sewer-gas, not only induces phthisis, pneumonia, and other lung affections, but largely influences the spread of zymotic disease and the severity of all kinds of diseases, however they may have been originated in the first instance. Pneumonia is frequently engendered by impure air, and it is now generally admitted that this filth-pneumonia, as it may be called, is infectious, and occasionally becomes epidemic. Then, again, there can be little doubt that it is this influence which changes pleurisy into empyema, simple bronchitis into broncho-pneumonia, and which serves to explain the frequency with which lung affections are associated with various infectious diseases, such as smallpox, measles, whooping-cough, and enteric fever.

2. *Sanitary Defects in and around Dwellings.*—As regards the defects themselves, they are of every variety and extent, and many of them palpable enough. Damp foundations, damp walls, imperfect ventilation, windows not made to open, roofs dilapidated and out of repair, floors uneven, general uncleanliness, overcrowding—all these constitute nuisances which are especially common in the dwellings of the poorer classes in town and country districts alike. Then, if there is no sink inside the dwelling, there is generally a drain near the front or back door to remove the slops, which is so badly laid and trapped that foul smells are constantly given off, and these are often aggravated by other nuisances. In country districts, for example, pig-styes, byres, and manure-heaps are frequently so close to the dwellings that the inside air is always more or less tainted. The closet accommodation, again, consists either of a foul privy, which, though sufficiently far removed, is so offen-

sive that it cannot be used without risk, or of a privy and deep ash-pit close to the house and in dangerous proximity to the well. Indeed, pollution of the well-water from closets, leaky drains, or manure-pits in farm-yards is the principal cause of the majority of the sporadic cases of enteric fever which are met with in country districts, and of much of the diarrhœa which becomes more or less prevalent during dry and warm seasons. Apart from overcrowding, then, it may be said that the gravest dangers to health connected with the dwellings of the poorer classes in rural and small urban districts are external rather than internal, and therefore it is essential that in making a systematic inspection of such premises special attention should be paid to the surroundings. The points to be noted on a detailed inspection are the following:—Date of inspection; name or situation of house; name of owner and occupier; number of inmates; number of lodgers, if any; number of living-rooms and sleeping-rooms (if overcrowding is suspected, the cubic space of the sleeping-rooms should be ascertained—see Chapter XVIII.); state of ventilation (note whether all windows are made to open, and whether every sleeping-room not provided with a fire-place has a ventilating opening of some sort in addition to window); condition of floors (whether they are uneven or out of repair); condition of walls (whether damp or dilapidated); condition of roof (whether it lets in the wet); general condition of premises (whether clean and in good repair); condition of drainage (if any drain enters the house, note whether it is properly disconnected, also note whether outside drains are well laid and properly trapped); nature of water-supply (if from a well, note whether there are any sources of pollution near, such as deep ash-pit, privy, cesspool of any kind, leaky drain, or manure-pit—if water is suspected, have it analysed); nature, situation,

and condition of closet accommodation (note whether closet is free from nuisance, whether there is a deep ash-pit in connection with it, whether, if not a pail-closet, it is situated at a safe distance from house or well, etc.); other nuisances (such as keeping of pigs too near dwellings, pig-wash cisterns, manure-heaps, etc.)

A detailed examination of all these various items is of course not necessary in the great majority of cases, but in making a systematic survey of a district it is essential that they should be noted in the survey-book (see Chapter XVIII.)

With regard to country mansions and the better class country houses, the dangers to health, if not more numerous, are certainly more serious, and for the most part are connected with the drainage or water-supply. Indeed, it is no exaggeration to say that grave sanitary defects will be found to exist in almost every country residence which has not been built or inspected within the last few years; and even in respect to new buildings it is lamentable to find that, owing to ignorance or neglect on the part of architect, contractor, or plumber, and sometimes of all three, the most serious blunders are still perpetrated.

One of the chief dangers in country houses attaches to the cesspool and the drains leading to it. The cesspool itself is generally some distance from the house, and is provided with an overflow which discharges into the nearest ditch or brook. It is rarely ventilated, but is usually completely covered up, and in any case is only cleaned out at long intervals, sometimes not for periods of years, and, to add to the danger, there is no disconnection by syphon-trap and ventilator between it and the house-drains. The drains are frequently either rubble drains, sometimes huge brick culverts, or common tile drains; but, whatever their exact structure, they permit

of free deposit, and are neither efficiently trapped nor ventilated. In close proximity to the walls, and sometimes under the floors, there are frequently supplementary cesspools or catch-pits, intended to retain solid matters, which are kept covered up with close-fitting slabs, and are so seldom opened and cleaned out that their very existence becomes forgotten. Into this system of drainage are discharged directly the pipes from sinks and sculleries, the overflow pipes from baths, the drains from cellars, the soil-pipes from water-closets, and very often the rain-water pipes.

The water-closets are generally situated somewhere in the centre of the house, badly lighted, badly constructed, and without proper ventilation. The soil-pipes are unventilated, and very soon become decayed and perforated. Very often the cistern supplying the closet is filled by means of a force-pump; and the same cistern, which is rarely cleaned out, and from which there is an overflow-pipe leading direct into the soil-pipe, also supplies the water for drinking and cooking purposes. In addition to all these sources of danger, the well itself may be close to one of these leaky drains or cesspools, or it may be near some outside offices of the worst form of privy or midden ash-pit, so that in any case it is constantly exposed to the risks of pollution.

In town houses of old construction the dangers to health are similar, though perhaps not so grave, inasmuch as the water used for domestic purposes is usually obtained from a public supply. But even this may become contaminated in the house-cistern if the overflow-pipe from the cistern, as often happens, discharges directly into the soil-pipe or the house-drain, or if the same cistern directly supplies the water-closet. The drains, for the most part, are laid underneath the house, and are often found to be constructed of brick, and generally so leaky

that the sewage percolates into the soil. In houses infested with rats it may be taken for granted that the drains are brick drains, or at all events that they are of very faulty construction. Even when drain-pipes have been used, they are frequently so badly laid and jointed that soakage into the soil becomes constant, and the inside air of the house always more or less contaminated. The closets, again, are generally of faulty pattern, and very improperly situated—it may be, in the centre of the house, on the landing, or sometimes in the bedrooms themselves; but in any case they are almost always badly lighted and ventilated. The soil-pipes, as in country houses, are usually inside the house, often very leaky, and seldom ventilated, nor are any other means of ventilation provided for the house-drains. Moreover, the waste-pipes from sinks, baths, and cisterns are seldom disconnected, so that channels for the entrance of sewer-air are to be found on every floor of the house, but especially in the basement, where, in addition to the leakiness of the drains, there are openings into them for the purpose of washing down the floors or draining cellars. These drain inlets are a permanent source of danger, because the traps are often bell-traps, from which the water evaporates, leaving practically untrapped openings; or if the water does not evaporate, the pressure of sewer-gas is so great that the water becomes saturated, and is constantly giving off foul emanations. Sometimes it happens that foul smells are detected in parts of a house where there are no drains or inside pipes discharging into them, and in these cases it is generally found that the foul air travels along rat runs, under floors, or behind skirtings; or it may be conveyed along the pipes containing the bell-wires; or it may find an entrance through the windows, from an adjacent rain-water pipe which is directly connected with the sewer. Of course foul smells in a house do not always indicate

the entrance of sewer-air, but they should never be tolerated a single day until the cause is ascertained and removed. Sometimes they are caused by the decaying body of a dead rat or mouse under the flooring, by dry rot, or, in rare instances, they have been found to proceed from some filthy paste used in papering the walls; but as a rule they point to defective drainage or escape of sewer-gas into some part of the house.

3. *Mode of Inspection.*—In making a detailed examination of the sanitary condition of a house, it is advisable that either an experienced builder, whose practical knowledge can be relied upon, or a sanitary engineer, be called in; and if there are plans of the house and drainage in existence, these should be obtained. In order to make the examination as thorough as possible, arrangements should be made to have the drains previously opened in several places, and concealed pipes and other fittings exposed to view. If the main drain is found to pass under the house, and to be badly laid or constructed, the instructions should be to have it taken up and relaid. Should it appear to be in good condition, it should then be tested as to its soundness, which is done by stopping it up at its lower end and filling it with water, and noting whether the water sinks or not, and at what rate. To test whether there are any deposits, a large volume of water should be poured down at the water-closet or sink, and if this appears foul and thick at the lower opening the drain is condemned as one of deposit. By noting the time which intervenes before the rush of water appears at the lower opening, an approximate idea may be obtained of the velocity of flow, or this may be determined with greater precision by pouring down some lime-water, and timing the flow. Leakages in the pipe-tracks or elsewhere, for the escape of sewer-gas, may be detected by pouring down some oil of peppermint at the closet or sink, or blowing

up at the opening made in the drain the smoke from burning brown paper, or by using the asphyxiator manufactured by Watts and Co. of Bristol.

The next point which should be ascertained is whether the house-drain is disconnected; and if there be a strong draught up the drain it shows that there is no intervening trap. As already shown in the by-laws laid down for the drainage of new houses, this disconnection of the house-drain by trapping, and providing a ventilating opening on the house side of the trap, is of the utmost importance, and it can readily be carried out in all cases, either by providing a ventilating pipe if the house is close to the street, or a simple open grating if there is sufficient space (see also Chap. XI.)

Before leaving the basement, all traps and branch drains should be carefully examined, and a careful search should be made for cesspools, if the existence of any is suspected. The condition of the flooring should also be noted as to dryness or otherwise, and the ventilation of all parts of the premises should be inquired into. Any water-closet on the basement which is found to be in the centre of the building, or to abut against any inside wall, should be condemned. Such closets are badly lighted and ventilated, and the drains leading from them are usually very defective, and liable to be choked up. If there are no underground cellars or basement, inquiry should be made as to whether the space beneath the floors is sufficiently ventilated, and whether there are any signs of rot. The dust-bin or ash-pit, and any outside offices, should also be examined, and if the ash-pit is found to be large and deep, it should be filled up to the ground level.

The details to which attention should next be directed are those connected with water-closets, sinks, baths, etc. If the closet is in the centre of the house, or abuts against

an inside wall, there can be no doubt of the faultiness of the arrangement. But even when the closet abuts against an outer wall the soil-pipe generally leads down inside the house into the drain, and not infrequently is taken through cupboards or larders. The track of the pipe should be exposed to view, and its soundness tested, by means of filling it with water or by the smoke test; but it is advisable to recommend, in any case, that the soil-pipe should be carried outside, and be ventilated by a pipe of the same dimensions extending to above the eaves. Small ventilating pipes, of about $\frac{3}{4}$ in. or $1\frac{1}{2}$ in. in diameter, are practically of little use, and often become choked up. The woodwork and fittings of the closet should next be examined, and any overflow-pipe from the safe should be made to discharge outside. If the pipes from sinks, lavatories, and baths are not disconnected—and it is seldom found that they are, except it be in new houses—instructions should be given to have all these pipes carried outside the walls of the house, and made to discharge on to trapped gratings communicating with the drain. Rain-water pipes which are found to be directly connected with the drain should also be disconnected, and any found passing inside the house should be carried outside.

The cisterns which supply the closets should next be examined, and it should be ascertained whether these supply the drinking water as well. If the water is stored in a large cistern under the roof, and is found to supply any taps, each closet supplied from this cistern should be provided with a small waste-preventing cistern, or steps should be taken to provide an independent supply for drinking and cooking directly from the main. The cistern itself should be examined as to cleanliness, and the overflow-pipe, which is often found to lead directly into the soil-pipe, should be carried outside.

In all houses provided with a public supply the use

of well water should be condemned, because, although it may be found to be fit for drinking purposes, the risk of pollution is always greatly increased in towns, on account of neighbouring drains and sewers. In country districts special attention should be directed to the water-supply, and any deep ash-pits, midden-privies, or cesspools near wells should be removed, and the drains examined. If the water is pumped up by means of a force-pump into a cistern, for the purpose of supplying the closets, it will generally be found that the cistern also supplies the housemaid's sink, and that at this tap the water-bottles, as well as bedroom utensils, are usually filled.

With regard to alterations generally, it should be recommended that unless special automatic flushing arrangements are provided, the house-drains should have a fall of at least one in thirty, and be at least 4 in., and never more than 6 in., in diameter. In cases where a proper fall cannot be obtained, a small self-acting flushing tank, in connection with the sink, should be provided. If the house-drains extend beyond the closets, the terminal end should be ventilated, as well as the soil-pipes, and no ventilating pipe should be less than 4 in. in diameter. Manholes should be placed at all bends in the drains so as to permit of ready inspection, and all down pipes should either be exposed to view, or, if encased, the casing should be made easily removable.

Although much improvement has been made of late years in the sanitary arrangements of dwellings, it should be laid down as a rule by every tenant in search of a house, that he should have the sanitary condition carefully inquired into, and any defects removed, before he takes possession. In London, Edinburgh, Gloucester, and several other large towns there are sanitary protection associations which undertake such inspections, and repeat them at stated times for a fixed fee or subscription; but it

would be a wise policy on the part of sanitary authorities throughout the country to undertake these duties themselves, and not limit their functions to the removal of actual nuisances, without interfering with many defects which only become declared nuisances when disease breaks out.

CHAPTER X.

HOSPITALS

In large towns the position of every hospital must primarily depend on the distribution of the population, or part of the population, whose wants it is intended to relieve, and hence the choice with regard to site is often very limited. Apart, however, from this restriction, there are certain considerations which ought always to influence the selection of site. For example, the future hospital should be erected in as airy and open a space as can be obtained, preference being given either to the outskirts of towns or to their largest interior unoccupied spaces. According to the recommendations of the Chirurgical Society of Paris in 1864, a free area of not less than 540 superficial feet should be allowed for each patient. This would give an acre of ground for a hospital containing 80 beds. In this country, on the other hand, an acre for 100 patients has been held to be sufficient, but a good deal will depend on the size of the hospital. Any defect in salubrity of site must be compensated by increased floor and cubic space.

No doubt, the most healthy sight for a hospital is in the open country, with a dry and porous soil, and slightly raised above the plain to facilitate drainage, but even a stiff clayey soil can be made perfectly healthy if proper precautions be taken in asphalting or concreting the foundations, and in providing plenty of free ventilation

beneath the ground-floors. While shelter from the cold north-easterly winds is desirable, it is an error to build hospitals on the face of a steep slope, or in any situation where there is an impediment to a free circulation of the air. Undrained marshy ground should be avoided, nor should houses or clumps of trees be in close proximity to the building.

For hospitals situated in the crowded localities of large towns, convalescent homes in the country, or at the seaside, are now being provided, and with marked advantage to the patients.

It is now generally admitted that, when large hospitals are rendered necessary, they should approximate as much as possible to the sanitary conditions which can only be ensured by small detached buildings. The application of this principle has resulted in the construction of hospitals on the pavilion system—a system which accommodates itself to almost any site and to any number of patients.

Section I.—Pavilion Hospitals.

In this description of hospital, each pavilion may be regarded as a separate hospital, and the impurities of every single ward are cut off from the other wards. The pavilions are united by a corridor for administrative purposes and for convenience, but are so arranged that a free circulation of air can always take place between them. In its simplest form a pavilion would consist of a single ward, with the necessary additions for administration. More frequently, however, it consists of two wards, one above the other, and, in some instances, of three wards, as in the Marine Hospital at Woolwich. Three-storied pavilions are objectionable, because their height necessitates a lofty corridor to unite them, and induces stagnation

of the air. With two-storied pavilions, on the other hand, the corridor need only be half the height of the pavilions. In large hospitals, such as the Herbert Hospital, the pavilions may be united in twos, end to end, with the corridor running between them, the stair-

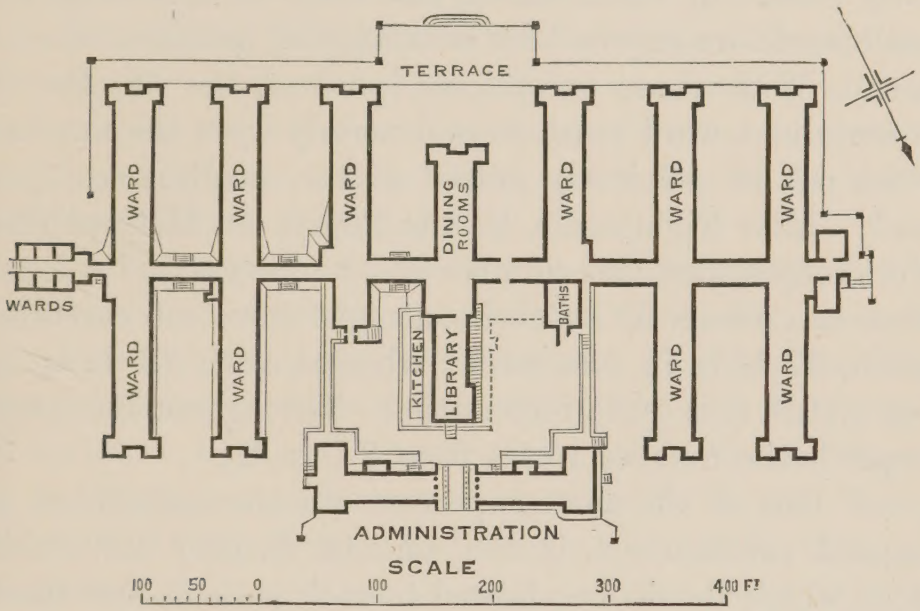

Fig. 7.—General Plan of Herbert Hospital, Woolwich.
(From "Construction of Hospitals," by DOUGLAS GALTON.)

case being, as it were, strung on to the corridor. The distance between the pavilions should be at least twice their height.

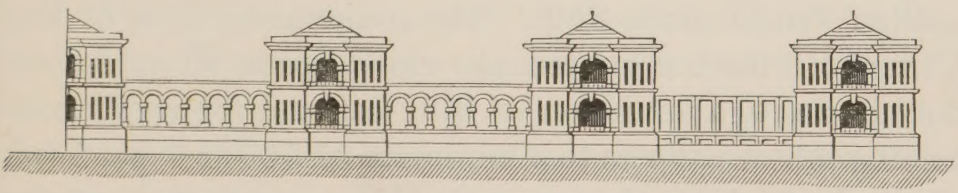

Fig. 8.—Sketch of the end of the southern Pavilions of Herbert Hospital, showing the elevation of the Corridor. (After GALTON.)

The basis or unit of hospital construction is the ward. The conditions which determine the size and form of a ward are the following :—

1. The number of patients which it should contain.
2. The floor and cubic space allowed to each patient.

3. The arrangements for warming, light, ventilation, and nursing.

1. The number of patients in a ward will depend on the size of the hospital, and, occasionally, on the nature of the cases. A cottage hospital, for example, will necessarily consist of small wards, and even in large hospitals small wards are required for isolating very severe or special cases. With these exceptions, however, the number of patients in a ward must depend mainly upon the number which can be efficiently nursed at the smallest cost per head. Miss Nightingale, in the Report on Metropolitan Workhouses, fixes this number at 32. She says, "A head nurse can efficiently supervise, a night nurse can carefully watch, 32 beds in one ward; whereas, with 32 beds in four wards, it is quite impossible." Throughout European hospitals the number varies from 24 to 32.

2. One of the most important questions attaching to hospital construction is the amount of floor and cubic space which should be allowed to each patient, and there is scarcely any question concerning which there has been so much discrepancy of opinion. Thus, Dr. Todd maintained that 500 cubic feet were sufficient; Dr. Burrows, 1000; the Army Sanitary Commission, 1200; and the Committee appointed to consider the cubic space of Metropolitan Workhouses, 850. The recommendations of this Committee further limited the cubic space allowance for dormitories to a minimum of 300 feet, and for wards containing infirm paupers to a minimum of 500 feet per head. There is no doubt, however, that, in consequence of the conflicting evidence on which the Committee had to base its recommendations, the difficulties of efficiently ventilating small spaces without draught were not sufficiently appreciated; but as reference has already been made with regard to this point, it need not be again discussed. Suffice it to say that General Morin, the greatest French authority

on ventilation, to whom the disputed subject was submitted, gave it as his opinion that, even for paupers who are not ill, he considered it "necessary not to descend below 880 cubic feet of space, and besides this the condition must be imposed of renewing the air in the proportion of 1060 cubic feet per individual per hour."

For ordinary hospital cases it is now generally admitted that a cubic space of at least 1200 feet should be allowed per patient, and for cases of infectious disease, or for severe surgical cases, as much as 2000, and it may be doubted if this be sufficient at all times.

On the superficial area per bed will depend the distance between the beds, the facilities for nursing, and the conveniences for ward administration. This, like the cubic space, has been variously estimated. Thus, in St. George's Hospital it is only 69 square feet; in St. Bartholomew's it is 79; in the Herbert Hospital, 99; in the Netley Hospital, 103; in Guy's, 138; and in the new St. Thomas's Hospital, 112. For all nursing purposes, Miss Nightingale maintains that at least 90 square feet should be allowed per bed, and this amount, according to Captain Galton, should be accepted as a minimum. Where medical schools are attached to hospitals, an extra allowance must be allotted for the requirements of clinical teaching. The space must also be greatly increased in fever or lying-in wards. The height of an average-sized ward should be 13 or 14 feet.

3. For providing sufficient light and for maintaining purity of the air, much depends on the width of the ward. Experience has shown that this should not be less than 24 feet, and not more than 30 or 35. In the new Leeds Hospital it is 27 feet 6 inches; in the new St. Thomas's 28 feet; and in the Herbert Hospital 26.

The ventilation of each ward should be entirely independent of the others, and to effect this, cross-ventilation

by means of open windows, aided by Sheringham valves, extraction-flues, and ventilating fire-places, is deemed to be the most efficient. In the summer months, when fires are not required, the windows should always be kept more or less open, except during rough, blustering weather.

When a window is allowed for each bed, which is sometimes the case, the wall-space between the windows should be six or eight inches wider than the bed. In the pavilion system, however, an allowance of one window for every two beds is generally considered sufficient, the beds being arranged in pairs between the windows, and separated from each other by a distance of at least three feet. The windows should reach from within two feet or two feet six inches from the floor to within one foot from the ceiling. The space between the end wall and the first window on either side of the ward should be four feet six inches, and the space between the adjacent windows nine feet, the windows themselves being four feet six inches wide. An end window to a long ward adds greatly to its cheerfulness, and aids materially in the ventilation of the ward. The ordinary sash window, made to open at top and bottom, is perhaps preferable to any other kind. To economise heat, plate-glass should be used instead of ordinary glass.

In addition to means of ventilation provided by windows, there should be a fresh-air inlet, furnished with a Sheringham valve, placed near the ceiling and between each window, or an upright ventilating tube of the kind recommended by Mr. Tobin. When the fire-places are situated in the external walls, two or three fresh-air inlets may be provided at equal distances along the centre of the floor, and communicating by means of transverse flues beneath the flooring with the external air. Such inlets are so far removed from the beds that the currents entering through them are not felt by the patients when in

bed, and they could be closed if deemed necessary during the daytime. The gratings covering them should be capable of easy removal, so that the flues may be cleaned out regularly.

The extraction-flues should be situated, if possible, on the same side of the ward as the fire-places, and should be carried above the roof and louvred. When not contiguous with a chimney, they should be provided with gas-jets to aid their extractive power. If the fire-places are situated in the centre of the ward, the extraction-flues should be placed in the opposite corners. The inlets to extraction-flues ought to be near the ceiling, but not in close proximity to the fresh-air inlets.

The fire-places best suited for infirmary wards are the ventilating stoves already described in the Chapter on Ventilation. But in addition to these, or in place of them, the fresh air might also be heated by hot-water pipes, coiled in boxes below each bed, as recommended by Dr. Parkes, or the pipes might pass along behind the skirting, the skirting being perforated or supplied with gratings opposite each bed for the admission of the heated air.

Every gas-jet in a ward should be furnished with a bottomless lantern, communicating with an extraction-tube, to carry off the products of combustion, or Rickett's ventilating globe lights should be used. (For particulars with regard to ventilation, see Chapter on that subject.)

The furniture in a ward ought always to be reduced to a minimum, and should never be cumbrous or bulky. Iron bedsteads are to be preferred to wooden ones, and thin horse-hair mattresses, placed on springs, or on woven wire mattresses, to thick flock or woollen mattresses. All bedsteads should be ranged at a short distance from the walls. Coverlets and blankets should be white or light-coloured, to show dirt, and ought to be frequently aired.

The other points of sanitary importance connected with a ward are its offices, and the materials employed in construction.

Ward-offices are required for facilitating nursing, and for the direct use of the sick. Thus every ward should have attached to it, at the end nearest the door, a scullery and a nurse's room, and, at the farther end a water-closet and ablution-room. The nurse's room should be light and airy, and large enough to be used as a bedroom. It should also be provided with a window, looking into the ward, for purposes of inspection. The scullery should be situated opposite the nurse's room, and ought to be fitted with a small range for warming drinks, preparing fomentations, etc.; a sink with hot and cold water laid on; and shelves and racks for dishes. It should be large enough for the assistant nurses to take their meals in.

The water-closet and ablution-room should be situated,

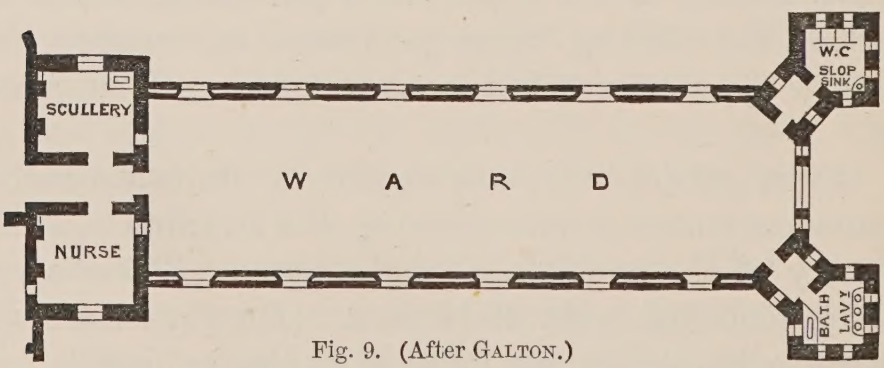

Fig. 9. (After GALTON.)

one at either farther corner of the ward, and both should be completely cut off by means of swing-doors and a lobby supplied with cross-ventilation from the ward. The water-closet apartment ought to contain one closet for every 10 beds, or 3 closets for 32, and should also be supplied with a sink and a urinal. Instead of a handle and plug for turning on the water for flushing, it is preferable to have a self-acting water-supply connected with

the door, because some patients are careless, and others are too feeble to raise the handle.

The ablution-room should contain a plunge-bath with hot and cold water laid on, a shower-bath overhanging the broad end of the plunge-bath, and a lavatory table fitted with basins, and also supplied with hot and cold water. There should likewise be room enough to contain a portable bath on wheels, a hip bath, and a foot-bath for the use of patients more or less bedridden. The pipes leading from the sink and lavatory table should not be boxed in, because the spaces thus enclosed become receptacles for dirt.

The supply of water should be ample, and the drainage and sewerage perfect. All closet-pipes should be ventilated and placed against outside walls, and all other pipes disconnected from the drains. The various fittings should be of a light colour, to show dirt, and thus ensure thorough cleanliness. The walls of closets and ablution-rooms should be lined with Parian cement, glazed tiles, or enamelled slate.

With regard to the materials of ward construction, it is now strongly recommended that floors should be made of hard wood, such as oak laid on concrete and well jointed; that the walls should be lined with Parian cement, or well plastered, periodically cleaned, and whitewashed or painted; and that the ceilings should be plastered and whitewashed, or painted a light colour. Floors of upper wards ought to be non-conductive of sound.

A ward thus constructed and arranged is in itself a small hospital, and the aggregation of ward units will depend on the number of patients to be accommodated.

In an average-sized hospital the administrative buildings occupy considerable space, and may be variously distributed. All of them, however, must be made entirely subservient to the requirements of the sick, and should

not interfere with the ventilation of the wards. Usually the administrative buildings are as follows :—

Kitchen, provision-stores, and stores for bedding and linen. These should be central.

Apartments for house-surgeon, matron, and servants ; consulting-room, waiting-room, surgery, drug-store, and operating-room ; all of them more or less central.

Laundry, mortuary, post-mortem room, disinfecting-room. These should all be detached from the building.

The night-nurses should have well-ventilated bedrooms at a distance from the wards, with all the necessary appliances for ablution, etc.

The staircases for patients should be broad and easy, and should be cut off from the connecting corridors by swing-doors. The corridors themselves should be as low as possible, well lighted, warmed, and ventilated.

According to Captain Galton, the administrative

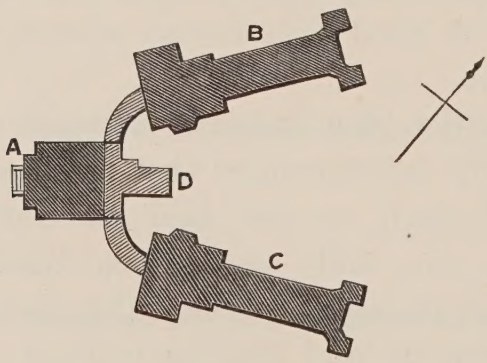

Fig. 10.—General Plan of Swansea New Hospital.
A, Administration ; B, Men's Wards ; C, Women's Wards and Out-patients ; D, Operating Room and Eye Ward. (After Galton.)

buildings take up about half the cubic space of the whole hospital. As very good examples of the pavilion form of hospital on the small scale, he instances the Royal Hants County Hospital at Winchester, the Buckinghamshire County Hospital at Aylesbury, and the New Hospital at Swansea.

With regard to the cost of pavilion hospitals, Captain Galton is of opinion that, with care and attention to economy in the design, a hospital for in-patients only, and built on a favourable site, should not cost more than from £90 to £120 per bed. The Leeds Hospital, which accommodates 350 patients, cost £197 per bed; the Royal Hants Hospital, with 108 beds, and including accommodation for out-patients, cost £229; and the Swansea Hospital, also including an outside-patient department, cost £142 per bed. Hospitals consisting of circular wards, as at Greenwich and Antwerp, have been advocated by some, but it is doubtful whether they possess any advantages over the pavilion system.

Day-wards, exercising grounds, and flower or winter gardens, are great additions to the sanitary advantages supplied by a well-constructed hospital. In summer, all the patients who are able to move about, and, indeed, most of those who are bedridden, should be allowed to remain during some part of every warm day in the open air. The flat roofs of the corridors, protected by awnings, could be utilised for the bedridden patients of the upper wards, while the corridors themselves might be appropriated by the same class of patients belonging to the lower wards. With very little extra expense the corridors could be converted into winter gardens during the colder months of the year, and might be occupied by patients in the daytime without interfering with any of the administrative arrangements.

Section II.—Cottage Hospitals.

The cottage hospital system, originated by the late Mr. Napper of Cranleigh, is based on the principles of providing hospital accommodation for the sick poor of rural districts, with as much of the surroundings of home as possible;

of permitting equality of privilege to subscribers in recommending patients, the patients themselves paying a certain sum weekly, according to their means; and of allowing any medical man practising in the district the use of the hospital for deserving cases under his care. The model cottage hospital should not have more than twenty beds, and must be under the management of one medical man as director, appointed either permanently or by rotation, the other medical men in the district holding office as honorary medical officers. The annual cost of the establishment is defrayed chiefly by voluntary contributions and partly by the weekly payments of the patients. These weekly payments, as already stated, are regulated by the means of the patient, and vary from 2s. 6d. when the Union has to help, to 5s. or 8s. when the patient has been earning fair wages, or belongs to a club. All fees allowed by the Union for accidents or operations are paid to the Union medical officer, in the same way as if he had attended the patient at his own home. Every subscriber, no matter what the amount of his subscription, should have equal privileges in recommending cases, and will generally be able to state what amount the patient whom he recommends can afford to contribute weekly. Cases of accident and emergency are admitted without order, but otherwise a recommendation from a subscriber must be procured, and this should in all instances be accompanied by a certificate from one of the medical staff, to the effect that the case is one deserving and fit for admission. Only those are admitted who cannot be efficiently treated at their own homes, while cases of infectious or incurable disease are excluded. In some few hospitals pay patients are admitted where there is sufficient accommodation, and it is rightly urged by Mr. Burdett in his excellent work on *Cottage Hospitals* that this system should be extended to all hospitals.

Experience has proved that in rural districts a cottage hospital of six beds will suffice for a population of 6000. The initial outlay will of course depend on whether a cottage which has already been built can be procured, and, if so, what alterations will be necessary to convert it into a hospital. If the hospital has to be built, the amount required may be estimated at £600, or about £100 per bed. In converting a cottage which has already been occupied into a hospital, the walls should be thoroughly cleaned, scraped, and afterwards replastered and washed with caustic lime. Attention must also be paid to the sanitary surroundings of the building.

The cost of furnishing a cottage hospital for six beds will amount to about £100, and the necessary surgical instruments to about £50. The maintenance per patient weekly would cost from 10s. to 15s., so that the hospital, when once started and properly furnished, will require for its support an annual income of at least £150, about £25 or £30 of which will be subscribed by patients.

Although the architectural arrangements may admit of many variations, the plan best suited for a cottage hospital of six beds should provide for a nurse's room, a three-bedded male ward, a two-bedded female ward, a single-bedded ward, which can be used as an operation room, a kitchen, which may also be used as a day-ward, a scullery, and a small mortuary. All the rooms should, if possible, be on the ground-floor, so that good roof ventilation and ample cubic space may be secured. Part of the roof should overhang, so as to form a sort of verandah for the use of patients. It need scarcely be added that a tasteful arrangement of flowers and shrubs in the space immediately surrounding the hospital will add greatly to its cheerfulness.

As regards nursing, cooking, and management, much will depend on the size of the hospital, but efforts

should always be made to secure the services of a trained nurse.

If a cesspool is used as the receptacle of excreta, it should be at a safe distance from the building, and constructed as described in the Chapter on Dwellings; but where no water is laid on, the pail or dry-earth system is to be preferred.—(See *Handy Book of Cottage Hospitals*, by Dr. Swete, and the much more exhaustive work, *Cottage Hospitals*, by Mr. Burdett.)

Section III.—Hospitals for Cases of Infectious Disease.

By the 131st clause of the Public Health Act, 1875, power is given to the sanitary authorities of any town or district to provide, for the use of the inhabitants, "hospitals or temporary places for the reception of the sick;" and when such provision has been made, any Justice may order the removal to the hospital of any person suffering from a dangerous infectious disease who is without proper lodging, or lodged in a room containing more than one family, or is on board ship. Judging from my own experience, however, and that of other health officers, it is very seldom that a magistrate's order is required for the removal of a patient, inasmuch as patients and their friends are, as a rule, only too glad to avail themselves of the advantages of a hospital of the kind, when proper isolation and adequate nursing cannot be procured at their own homes.

In a Memorandum of the Privy Council, printed in the Appendix to the First Report of the Local Government Board, it is recommended, as a condition of the first importance, that the accommodation for isolating cases of infectious disease shall be ready beforehand; and further, that it shall be sufficient for the treatment

of different infectious diseases separately. The amount of accommodation required will of course vary for different places. As regards villages, for example, it is recommended that "each village ought to have the means of accommodating instantly, or at a few hours' notice, say four cases of infectious disease, in at least two separate rooms, without requiring their removal to a distance. A decent four-room or six-room cottage, at the disposal of the authority, would answer the purpose. Or permanent arrangement might be made beforehand with trustworthy cottage-holders not having children, to receive and nurse, in case of need, patients requiring such accommodation. Two small adjacent villages (if under the same Sanitary Authority) might often be regarded as one."

If further accommodation be at any time required, neighbouring cottages should be hired, or tents or huts may be erected on adjacent ground.

Practically, however, it is found that Sanitary Authorities are generally so averse to providing any accommodation of the kind, unless under the stern pressure of an epidemic, that in rural districts, especially, the health officer may consider himself fortunate if he succeeds in obtaining a place sufficiently central to meet the requirements of a whole union, or at least the most populous parts of it. With a good ambulance, patients, if fit to be moved at all, can, I believe, be moved a distance of about six or eight miles without risk. In reference to this point, Dr. Thorne, in his exhaustive report on Infectious Hospitals, says: "It is not that removal for a distance of some five, and even in isolated instances eight and ten, miles in a well-constructed ambulance, and over ordinarily good roads, has appeared to do harm to the particular patient, provided the removal has been effected at an early stage of the

disease. By far the greatest difficulty in the matter of distance has been found, as a rule, to lie with the relatives and friends of the patients, who assent much more readily to removal to hospital if it be within such distance as to enable them, without much trouble and without material interference with their business and other avocations, to make frequent inquiry as to the patient's welfare. In rural districts, the question of distance is usually less thought of than in urban districts, especially when the hospital to which removal is effected is in or near some centre to which the population often travel in connection with their daily or occasional pursuits." Then, too, it was found in the course of Dr. Thorne's inquiry that strong objection was often raised to the removal of patients from one district to another, as from rural districts in the neighbourhood of large towns to hospitals situated in those towns, even when arrangements had been made between the Sanitary Authorities for the reception of patients from adjoining districts.—(See *Tenth Annual Report of the Local Government Board*, 1882.)

The question here arises, and it is a somewhat difficult one to answer, What should be the ratio of beds to the population for whose wants the hospital is to be provided? Dr. Buchanan, in a very able address delivered in 1876 to the Medical Society of London, lays down the ratio of one bed to every 1000 inhabitants, and no doubt, taking this as an average estimate, it may be considered as fairly accurate. But much will depend upon the special circumstances of the district and population. For example, a poor crowded district will require a larger amount of accommodation than a district not crowded, and whose inhabitants are on the whole well off. In the latter case, the ratio of one bed to every 2000 inhabitants, with means for temporary extension, if it should be required, might be considered sufficient.

It need hardly be said that the greatest difficulty is frequently experienced in obtaining a site. Vested interests at once take alarm because the popular prejudice against living in the vicinity of such hospitals is so great that property will, for the time being, depreciate in value. The site, therefore, which may be ultimately fixed upon may not be free from objection, but it should always be such that no sanitary objection can be raised against it. If the soil is stiff and clayey, special care ought to be taken, by means of drainage, a free use of concrete or asphalt, and abundant ventilation, to secure perfect dryness of the building. The building itself should be sufficiently central as regards the distribution of the population of the district, sufficiently accessible from all parts of the district, and, if possible, well isolated. In rural or suburban districts, there ought to be no difficulty in obtaining an abundant supply of good water, nor any difficulty in getting rid of the excremental matters and slops.

The question of cost of site will of course vary immensely according to the circumstances of the district, while the amount of space required will also vary very much. But, speaking roughly, no site, to afford sufficient isolation, should be less than one acre in extent, and a hospital, say of thirty beds, would require about three acres. Then, too, the site should be surrounded by a suitable fence to cut off all communication except through the lodge entrance, and such fence Dr. Thorne recommends should be a wall about 6 feet 6 inches high. It is also insisted on by the Local Government Board that the building should be at a distance of at least 40 feet from the nearest boundary or fence. The following table from Dr. Thorne's report gives important particulars with regard to the best arranged permanent hospitals which he visited:—

District.	Estimated Population.	Number of Beds.	Present Bed-rate per 1000 of Population.	Floor-space per Bed, in Square Feet.	Ward capacity per Bed, in Cubic Feet.	Cost of Hospital, excluding Cost of Site.	Cost per Bed, excluding Cost of site.
						£	£
Berkhampstead, rural . .	11,000	8	0·7	144	2000	2,162	270
Cheltenham, urban . .	44,000	32	0·7	Varies; mean is 144	Varies; mean is 2300	11,121	347
Darlington, urban . .	35,000	44	1·3	144 to 175	2000	10,123	225
Folkstone, urban	18,700	14	0·7	140	2000	2,800	200
Lewes, combined districts .	11,200	12	1·1	144	2000	1,975	164
Middlesborough, urban . .	56,000	32	0·6	122 to 180	1620 to 2100	6,829	213
Sheffield, urban	285,000	64	0·2	138	1810	19,785	309
Solihull, rural	20,000	12	0·6	144 to 156	2000 to 2184	2,892	241
Tonbridge, urban . .	10,000	12	1·2	140	2000	1,394	116
Warrington, urban . .	42,000	28	0·7	144 to 175	2058 to 2529	6,555	234
Weymouth, port	?	26	?	144 to 169	2014 to 2028	5,135	192

Permanent hospitals should be built of brick or stone, and not of wood or corrugated iron, because, apart from other reasons, it was found in the course of Dr. Thorne's inquiry that it was very difficult to maintain in the latter class of buildings a sufficiently warm temperature in cold weather. They should be built on the pavilion system, and consist of an administrative block; at least four wards, in two separate pairs, in which patients of both sexes, suffering from two different infectious fevers, can be

simultaneously treated; and certain outbuildings, such as mortuary, laundry, etc.

The administrative block is usually built in excess of the requirements of the permanent pavilions, so as to be commodious enough for any future extensions, should they become necessary; and where it is desirable to economise space, it may be a two-storied building. It should only communicate with the pavilions by means of covered passages with free cross-ventilation; and should be so situated that persons can enter it without passing close to the pavilions.

The pavilions themselves are generally one-storied buildings, but where a site is necessarily limited Dr. Thorne saw no reason to object to two-storied pavilions, provided of course that only patients suffering from one kind of infectious disease are treated in the same pavilion—the patients of one sex on one floor, and the patients of the other sex on the other floor. The distance between the several pavilions and between them and the administrative block should be equal to one and a half times their height, and when the buildings are of unequal height, it should at least be equal to the full height of the higher of the adjacent buildings. Dr. Thorne further recommends that in the case of a smallpox pavilion, the separation between it and the other hospital buildings should, if possible, be even still more complete, or it should be, as at Folkestone, an entirely separate institution. At Folkestone, too, arrangements have been made for the reception of better class patients into a separate block of small wards; and there is no doubt that such an addition to most infectious hospitals would be a great boon to paying patients, besides affording means for isolating noisy or delirious patients and doubtful cases.

The construction and arrangement of the ward pavilions are so similar to the details already given with regard

to general hospitals that only a few additional particulars may be given here. The cubic space per bed, according to the memorandum of the Local Government Board, should be at least 2000 feet, and the minimum floor space per bed 144 square feet. The height of the wards should be about 14 feet, and no additional height should be taken into account in reckoning the cubic space. The floors should be closely jointed, the walls either covered with Parian cement, or made smooth and limewashed and coloured, and flat ceilings without cornices should be preferred to pitched roofs. The windows should be double-sashed, and be evenly distributed in the opposite walls, so as to ensure efficient cross-ventilation. The best arrangement is found to be that which provides for one window between every two adjacent beds, and one near the angles of the ward beyond each end bed. They should reach from about 3 feet above the floor level to within 6 inches of the ceiling or wall-plate, and the amount of window space should be in the proportion of 1 square foot to about 70 cubic feet of ward space—too much window space having been found to interfere with the equable warmth of the contained air.

In addition to the window ventilation, Dr. Thorne recommends that there should be ventilating openings under each bed, and just above the floor level, and each capable of being closed by means of a small sliding door on one or other side of the ward, according as the direction of the prevailing wind may determine. The ward ventilation should be supplemented by vertical enclosed shafts passing through the roofs, or special flues opening near the ceiling, and carried alongside the chimney flues.

With regard to warming, it was found that open fire-places are best adapted for ward purposes, and preferably those of the ventilating kind. When wards exceed 30 feet in length, ventilating stoves, having an open fire-place

both back and front, should be provided in the centre of the ward, or instead of these close ventilating stoves may be substituted.

In connection with each ward pavilion there should be an entrance lobby, a nurse's room fitted with fixed windows to command a view of either ward, a room in which to store food, and a linen store. In small hospitals the nurse's room is often fitted as a ward kitchen, and provided with a scullery sink. In two-storied pavilions similar apartments should occupy the end of the ward which adjoins the entrance lobby and staircase. At the opposite end of the ward, closets, sinks, and bathing accommodation should be provided in a building projecting from the main pavilion, as already described in Section I., and separated by a lobby provided with efficient means of cross-ventilation. When no separate bath-room is provided, a movable bath on wheels is found to answer the requirements of small hospitals.

It need hardly be said that the drainage should be perfect in all its details, and the water-supply abundant and wholesome. Where there are no public sewers the closets should be dry closets, provided with movable receptacles, which can be removed through a small doorway in the outside wall, and the best way of treating the slops is by sub-irrigation from a Field's syphon flush-tank. (See Chapter XI., Section VII.)

The furniture of the wards should be simple and neat; and, for obvious reasons, all bed-curtains, carpeting, or matting should be prohibited. The best kind of bedsteads are iron bedsteads, provided with wire woven mattresses, and thin horse-hair beds, which can be easily disinfected in a disinfecting chamber.

The outbuildings should consist of a porter's lodge, if the hospital is of considerable size, a mortuary, a laundry, an ambulance shed, and a disinfecting chamber, and if

necessary a post-mortem room—all of which should be built at a safe distance from the pavilions.

At the date of Dr. Thorne's inquiry, the most efficient disinfecting chamber was the one devised by Dr. Ransome, Nottingham; but according to Dr. Parsons, Lyon's steam disinfecting chamber gives the best results. (See Chapter XVI.)

Temporary extension of the accommodation of any hospital may be provided in the summer and autumn by tents, and in the winter and spring by wooden huts. The tents recommended are, the regulation bell-tent of the War Department, 513 cubic feet space, and the regulation hospital marquee of 3000 cubic feet space. The former should not contain more than one patient, nor the latter more than three. The ground on which they are pitched should be kept dry by means of trenches around and between them; the floors should be boarded; the approaches paved or boarded; and the tents themselves should be everywhere distant from each other at least a diameter and a half. All slops and refuse matter should be carefully removed. In the late outbreak of smallpox at Wednesbury, large double canvas tents were used with great success, and it was found that they could be efficiently warmed with hot-water pipes.

With regard to hut, "dryness of site is, as in the case of tents, of the first importance. Each hut should be trenched round. Its floor should be raised a foot or a foot and a half from the earth, so as to permit the free under-passage of air; but care must be taken to prevent the lodgment of moisture or impurities beneath the floor. A distance not less than three times the height of a hut should intervene between any two huts, and each hut should be so placed as not to interfere with free circulation of air round other huts. In huts, as in permanent buildings for the treatment of infectious diseases, not less than 2000 feet cubic space, with 144 square feet of floor,

should be given to each patient. The ventilation of huts, also, is of equal importance with that of permanent hospital buildings. It is best secured by the combination of side-windows with roof-opening, the latter protected from rain, and running the whole length of the ridge of the roof. The windows, capable of being open top and bottom, should not be fewer than one to each pair of beds, or in large huts one to each bed, nor should be of less size than the sash-window in common use for houses. The ventilating opening beneath the ridge may have flaps, movable from within the hut by ropes and pulleys, so that the opening to windward can be closed, if necessary, in high winds. Double-walled wood huts may have additional ventilation by the admission of air beneath this outer and inner wall, and its passage into the interior of the hut through openings with movable covers at the top of the inner lining. The roof should be covered with waterproof felt; the edges of the felt fastened down by strips of wood, not by nails. The hut should be warmed by open fire-places, fixed in brick stove stacks placed in the centre of the floor, the flue being carried through the roof."—(See *Memorandum of Local Government Board.*)

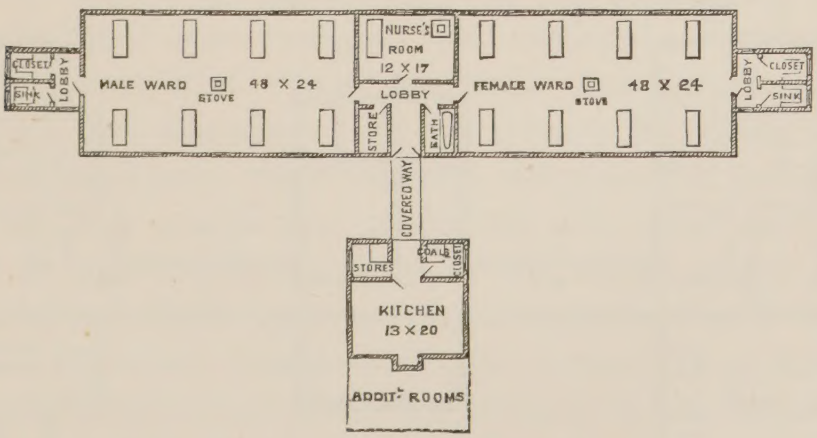

Fig. 11.

The above is a ground-plan of a hospital hut for

eight patients of each sex, having the same infectious disease.

Fig. 12 is a ground-plan of an extension of hut hospitals for ten patients of each sex, having the same infectious disease, where plenty of ground is available.

Both these plans are copied from the Memorandum of the Medical Department of the Local Government Board already referred to.

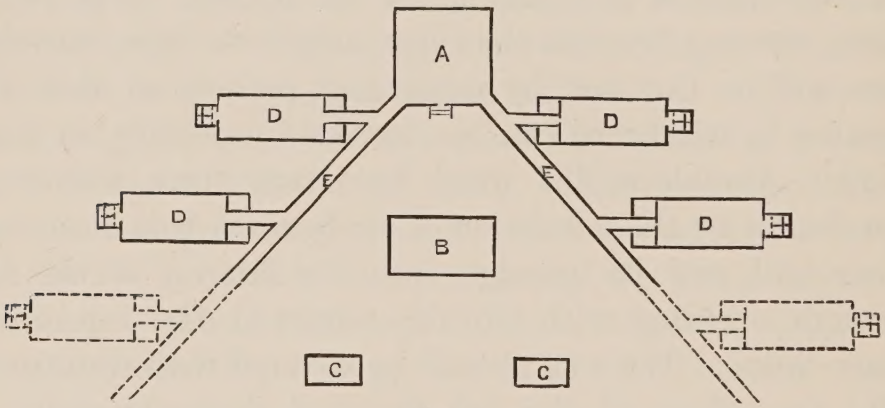

Fig. 12.

Fig. 12—A, Administrative Buildings (Kitchen, Stores, Offices, Nurses' Bed-rooms, etc.); B, Laundry, etc.; C, Disinfection, Dead-house, etc.; D, Huts for 10 patients each, with Scullery and Bath-room at end, and Closet and Sink at other end of each; E, Open Corridors. The dotted lines show direction of further extension.

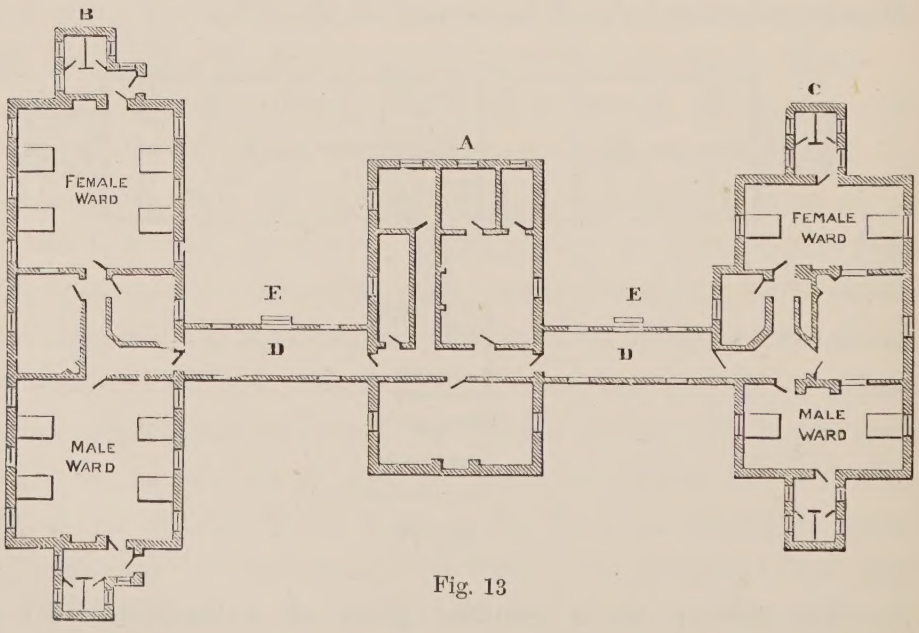

Fig. 13

Fig. 13 is the ground-plan of a hospital which was built in the Solihull Union, which forms part of the Mid-Warwickshire sanitary district, in 1876. The general principles of the plan are those laid down in the Local Government Board Memorandum, although the details were modified to suit local circumstances. The central block A contains a kitchen, bed-room, larder, small surgery, etc. There is a doorway, E, in each corridor, D, so that the patients in the blocks B and C can be kept completely apart if required. In addition to these blocks there are outbuildings containing a porter's lodge, a disinfecting chamber, a dead-house, a wash-house and laundry, and a shed for an ambulance. The population of the Union is about 21,000, and the site covers two acres of ground, and cost £400.

As an illustration of the value of hospital provision for infectious cases, I may quote Dr. Buchanan's remarks concerning the smallpox hospital in Cheltenham, from the address already referred to:—"Here fourteen beds are permanently provided for smallpox cases in an admirable little hospital that is devised to suit the wants of well-to-do people, as well as those who may be sent to it by the public authorities. In six months of last year smallpox was brought into Cheltenham no less than six times, from Gloucester, from Birmingham, from Liverpool, and elsewhere. Seven persons ill of the imported disease were taken without delay to the Delaney Hospital, and except one individual, who was also removed to the hospital, nobody in the town caught the disease from these centres of contagion. There was literally no other smallpox in the town. How much there would have been if, in the absence of the hospital, the seven importations had been allowed to spread their contagion in a widening circle round each, can of course only be a matter of surmise."

The management of a small infectious hospital would be very much like that already described as suitable for a cottage hospital. A medical officer should be appointed who would have full powers as superintendent, but any patient should have the option of being placed under the care of his own medical attendant should he desire it, provided he pays for the cost of attendance. No obstacles ought to be thrown in the way of admitting patients, and no payment should be insisted on except in special cases or where private wards are provided. A skilled nurse can always be obtained on the shortest notice from any of the excellent nursing institutions advertised in the medical papers. At times when the hospital is not occupied, the building and bedding should be kept clean and well aired. Strict rules of management should be drawn up.

An indispensable adjunct to a hospital is a well-constructed ambulance, and here it may be mentioned that the carriage designed by Mr. Furley of the St. John's Ambulance Association has been specially commended. But a one-horse omnibus, with door behind and easy springs, can be converted into a very comfortable ambulance by taking out all the lining and polishing or varnishing the woodwork. The space beneath the driver's feet should be utilised in extending the internal space, and this should receive the foot-end of the stretcher. The stretcher should be made of wire or wicker work, and the handles should be jointed, so that when the stretcher is placed in the ambulance the handles will not encumber any of the space. Instead of a stretcher, a net hammock slung on hooks will be found to be a very comfortable mode of conveying children and young persons; indeed, for that matter, there ought to be no difficulty in slinging the stretcher itself by means of strong indiarubber bands attached to properly fixed hooks

or bars. Such an arrangement would remove much of the discomfort arising from jolting, which good springs do not always prevent, and it would cost little, either in ingenuity or as regards expense, to carry it out. In addition to the stretcher or hammock, there should be a hinged seat near the door for the attendant, and one or two hot water cans to secure sufficient warmth in cold weather and during a long drive. After being used, the ambulance should be thoroughly disinfected by being washed with a strong solution of sanitas, or any other disinfectant which does not leave a disagreeable smell afterwards. The comfort of the patient would be greatly increased if, in addition to good springs, the ambulance were provided with noiseless wheels having indiarubber tires. Particulars with regard to a disinfecting chamber will be given in Chap. XVI.

When an infectious hospital is required at very short notice, it may be run up of wood or of corrugated iron and wood, such as the huts designed by Humphreys and Co. of Knightsbridge, London; or, to meet sudden emergencies, it has been suggested that "flying hospitals," consisting of two or more large vans, which could be moved by road or rail, would be found to be of immense service, and they could no doubt be so arranged as to be made quite as comfortable as hut hospitals. Double canvas tents pitched on wooden floors have also been utilised to meet an emergency at Grantham, Newark, Wednesbury, and other localities, and with a large amount of success. If a number of tents are used, as at the Darenth Metropolitan Smallpox Hospital, near Dartford, they are most conveniently warmed by hot-water pipes; but isolated tents, such as those manufactured by Edgington and Co., London Bridge, can be warmed by stoves. Patent portable hospitals on the Decker's system, for small districts, answer admirably, and are in use at King's

Norton, near Birmingham, Orsett Union, Essex, and other places. The agents in this country are Puggard and Galschiot, Eastcheap, London.

At seaport towns it is proposed to use hospital-ships of the "Dreadnought" type, but any hull of an old vessel capable of floating, and large enough, would suffice. Wooden huts erected on the upper deck would supply the ward accommodation, while the body of the vessel could be utilised for the administrative department. Such hospital-ships would prove of immense value in the event of cholera again visiting this country, and are in use for smallpox cases on the Thames.

Section IV.—Mortuaries.

In connection with this subject of hospitals, some hints may be given with regard to public mortuaries. By Section 141 of the Public Health Act, 1875, it is enacted that any Sanitary Authority, whether urban or rural, "may, and if required by the Local Government Board, shall, provide and fit up a proper place for the reception of dead bodies before interment, and may make by-laws with respect to the management and charges for the use of the same; they may also provide for the decent and economical interment, at charges to be fixed by such by-laws, of any dead bodies which may be received into a mortuary." Further, it is enacted by Section 142 that "when the body of one who has died of any infectious disease is detained in a room in which persons live or sleep, or any dead body which is in such a state as to endanger the health of the inmates of the same house or room, any Justice may, on a certificate signed by a legally qualified medical practitioner, order the body to be removed at the cost of the Local Authority to any mortuary provided by such Authority, and direct the

same to be buried within a time to be limited by such order."

Such are the provisions of the Public Health Act, but except it be in large towns—and even in them there is still a great lack of adequate mortuary accommodation—little or no effort has been made by Sanitary Authorities in this direction, and hence Section 142 becomes practically inoperative. Mr. Burdett, in his excellent work on *Cottage Hospitals*, already referred to, suggests that not only should mortuaries be provided at all hospitals, but that Sanitary Authorities should contract with hospital managers to receive bodies from overcrowded homes on payment of certain fees or of a fixed annual subscription. The estimated cost of a small brick building, with two compartments, including mortuary, two waiting-rooms, and a disinfecting chamber, is laid down at between £200 and £300. For large towns the mortuary should be sufficiently capacious to hold ten or twelve bodies placed in shells or coffins resting upon trestles or movable iron brackets fixed around the sides of the building. The post-mortem room should be adjoining, but quite distinct from the mortuary. It should be well lighted, well ventilated, and be provided with special appliances for post-mortem examinations. There should also be a room or rooms for the accommodation of the coroner and jury in inquest cases, as at Islington, Clerkenwell, and the City of London. As regards the regulation and management of mortuaries, a large amount of valuable information is given by Mr. Burdett in his work on *Cottage Hospitals*.

CHAPTER XI.

REMOVAL OF SEWAGE

THE term sewage may be conveniently used as indicating the excrementitious matter thrown off by the bowels and kidneys, and, indirectly, the refuse, whether solid or liquid, which is constantly accumulating in inhabited places, and requires to be constantly removed if cleanliness and health are to be maintained. A consideration of this subject will therefore have reference not only to the different methods of excretal removal, but also to scavenging.

Although in thinly-populated districts it might be inferred that the disposal of the excreta and house-refuse ought to be attended with very little risk, it is found practically that, owing sometimes to nearness to the house, or at other times to being close to the well, the midden or cesspool frequently becomes the cause of severe illness, and, if the contents are allowed to accumulate, is always a source of real danger. Even when a house stands widely apart from every other, the occupier cannot safely neglect the sanitary obligation which rests upon him of disposing of his house refuse, whether solid or liquid, so that there shall be no foul smells to taint the air, nor foul leakage from drains or cesspools to pollute his drinking water or render unhealthy the walls and foundations of his dwelling. And in proportion as houses are gathered together in towns or large villages, it

need hardly be said that this sanitary obligation becomes more and more important. Yet nothing is more clearly established in the numerous reports of the Medical Inspectors of the Local Government Board and in published reports of health officers from all parts of the country, than the gross and utter neglect which still prevails with regard to that continuous and systematic removal of all filth which can alone ensure even an approach to cleanliness.

In describing briefly the various methods of sewage-disposal, it will be convenient to discuss the subject under the following sections:—

1. The water system.
2. The privy or midden system.
3. The pail system.
4. The dry system.
5. Lieurnur's, and other continental systems.
6. Systems best suited for rural districts.
7. Disposal of slops.
8. Public scavenging.

With regard to systems other than the water-carriage system, most of the information here collated has been obtained from the valuable joint-report of Dr. Buchanan and Mr. Netten Radcliffe (see Mr. Simon's *Twelfth Report* to the Privy Council), and from the still more elaborate report of Mr. Netten Radcliffe, contained in No. II. of the New Series already referred to, as well as from the report on sewage-disposal issued by the Local Government Board in 1876, and other works.

Section I.—The Water System.

Where there is no unusual difficulty in dealing with the sewage at the outfall, there can be no doubt that the water-carriage system of sewage removal is the one best

suited for large towns. In the great majority of towns, however, this difficulty has become so very serious, or the drainage in parts is so defective, that the water system has been supplemented by other plans, varying according to local requirements, but all of them intended to deal more particularly with fæcal matters. Apart from considerations of cleanliness and convenience, this system possesses the additional advantage of employing the same channels for the removal of sewage which are required for the removal of waste water; and not only so, but the waste water can in this way be utilised as a very efficient vehicle for the conveyance of the excreta. In most cases the subsoil water, surface water, and the water used for domestic purposes, are all eventually discharged by the same channels, so that the drainage and sewerage of a town usually form part of the same system.

1. *Drains and Sewers.*—In any system of drainage intended to carry off surface water and drain the subsoil, it is necessary that the drainage channels should have sufficient area and declivity to maintain the discharge of the water which they receive at all times, and at its fullest flow. This quantity will of course depend chiefly on the rainfall of the locality to be drained, and upon the amount entering the drains from other sources. Thus, in country districts, the water to be carried off may be partly derived from porous strata, which have their gathering ground beyond the boundary ridges of the drainage-area; and in towns, the water-supply artificially brought in is added to the amount derived from the drainage of the inhabited district. Moreover, as the soil acts as a kind of reservoir, the water does not enter the drains in the open country as rapidly as it falls—indeed a considerable portion of it is evaporated or absorbed by vegetation; but in towns it runs off the roofs and paved or macadamised surfaces almost as fast as it is delivered.

Guided by these considerations, engineers have estimated that the capacity and declivity of the water-channels for country districts should be sufficient to carry off the greatest available rainfall occurring during twenty-four hours in that space of time, whereas in towns they should be capable of discharging the greatest hourly rainfall on the area, and the greatest hourly supply from other sources. The depth of the greatest hourly rainfall is estimated by different authorities at from half an inch to an inch.

In small towns, where the storm-water, or greatest hourly rainfall, may be passed over the surface without causing injury, the main sewers need not be constructed of a capacity to discharge it,—a plan which has been carried out at Penzance and Carlisle. In other towns, again—as at Dover, Ely, Rugby, etc.—most of the storm-water is carried off by the old drain-sewers, and the sewage by separate pipe-sewers; or pipe-sewers are used exclusively for the sewage, and separate drains are constructed for the subsoil and storm-waters. This is called the separate system, and it is now adopted in all new plans of drainage which provide for the treatment of the sewage.

The advantages of the pipe-sewer system are, that the pipes, if strong and well jointed, prevent percolation; that they can be quickly laid, and require much less excavation than brick sewers; that they can be made of various curves to suit different positions; and that, with a proper declivity, they are not liable to get fouled. Another great advantage depends on the fact that the sewage can be treated without excessive dilution, and when a pumping-station is required at the outfall the original cost and working expenses are much lessened. On the other hand, the pipe system does not fully ensure the important hygienic condition of drying the subsoil if separate drains are not laid down, or unless subsoil pipes

are conjoined with sewer pipes, as in the system devised by Messrs. Brooke and Son of Huddersfield. Brick sewers, however, as they are usually constructed, do act efficiently as subsoil drains, but at the same time it must not be forgotten that all such sewers are more or less leaky, and are therefore a constant source of danger to any wells or water-mains which may be near them.

(1.) *Construction of Sewers and Drains.*—The main drains or sewers of large towns are underground arched conduits, built of brick in cement, and should be perfectly water-tight. They are generally laid on a bed of concrete, to prevent sinking of any part of the track, and consequent fracture. The cross-section preferred for them is an egg-shaped oval, with the small end downwards, and with a width of at least 2 feet, to allow men to enter them for the purpose of cleansing and repair. They should be laid out in straight lines and true gradients from point to point, so that the current shall have a velocity of not less than 1 foot, and not more than $4\frac{1}{2}$ feet, per second. At each principal change of line or gradient, arrangements should be made for inspection, flushing, and ventilation; and at all junctions or curves the declivity should be increased, to compensate for friction. No sewers or drains should join at right angles, or directly opposite the entrance of others. Tributary sewers should deliver in the direction of the main flow, and should also have a fall into the main at least equal to the difference between their diameters. Main sewers of medium and smaller dimensions are made of glazed earthenware pipes.

Surface-drains or gutters communicate with the under-ground drains by gulley-holes, which are covered with gratings, and generally fitted with syphon-traps to prevent the escape of foul air. Branch drains, leading from the houses and from the adjoining ground, are made of glazed earthenware pipes, bedded on concrete,

and well jointed in hydraulic mortar or cement. They should never be less than 4 inches in diameter, and should have a declivity sufficient to ensure a velocity of flow of at least $4\frac{1}{2}$ feet per second, to prevent the formation of deposits. All junctions with other drains or sewers should be curved or acute-angled, and, whenever practicable, they should be made in a vertical or transversely inclined, instead of a nearly horizontal, plane. Pipes of small size should always be joined on to pipes of larger size, as 4-inch pipes into 6, 6 into 9, and 9 into 12.

No drain should ever commence in the basement of a house, otherwise the up-draught produced by the increased inside temperature will occasionally draw the air through any trap. House-drains should never be less than, or seldom exceed, 4 inches in diameter, and, as previously shown, should be completely disconnected from the public sewers. Cellars should be drained by making the drain so as to discharge upon a trapped grating communicating with the drain outside the wall of the house, or, if this cannot be readily effected, the drain should be trapped, and well ventilated either by a special pipe or an open grating. Where houses have to be drained from back to front through the basement, the drain-pipes should be carefully jointed, bedded in concrete, and ventilated back and front outside the walls of the house. Sink-pipes, and pipes from cisterns, lavatories, or baths, should never communicate directly with the drains, but should always be carried outside the walls of the house, and be made to discharge on to open trapped gratings communicating with the drains. All soil-pipes should be sufficiently ventilated, and no other pipes, such as overflow-pipes from cisterns, should open into them.—(See Chapter on Dwellings.)

(2.) *Ventilation of Sewers.*—In order to prevent concentration or stagnation of the gases which are largely given off by sewage, it becomes a matter of the utmost

importance to provide numerous openings communicating with the sewers, to ensure free ventilation. Main sewers, with steep gradients, should have a manhole, a tumbling bay, and double ventilating arrangement, at intervals of not less than 300 yards. The tumbling bay or fall is provided to allow of a flap valve being applied to the

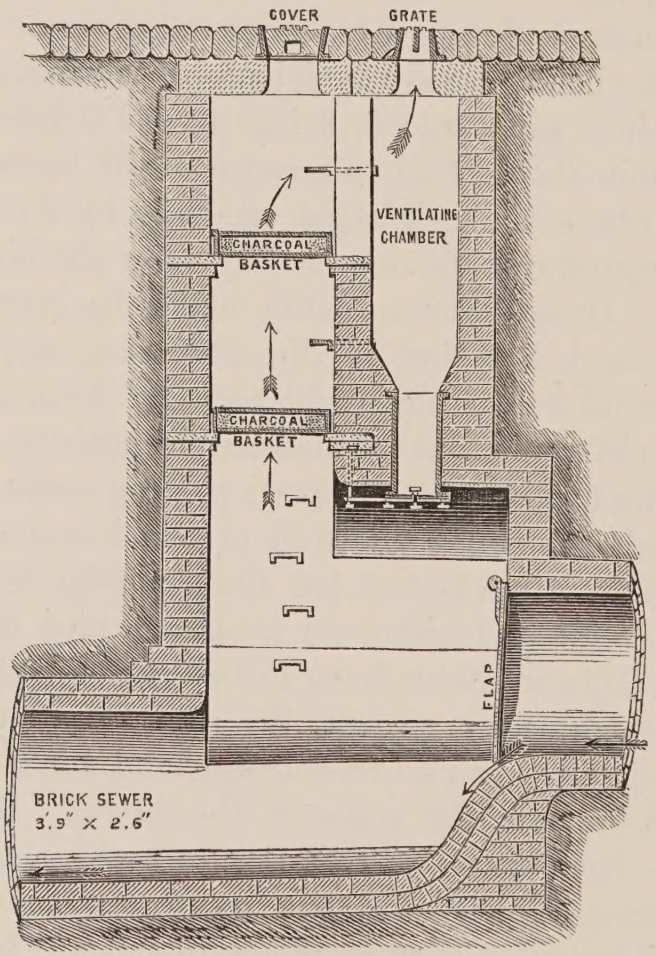

Fig 14.—Manhole, Tumbling Bay, and Double Ventilating Arrangement. (After Rawlinson.)

discharging end of the sewer, and thus compel the gases to ascend through the ventilating shaft. One or more charcoal baskets may be placed in the manhole to deodorise the sewer-air as it escapes, and before it enters the ventilating chamber, but charcoal should never be used

when it can be avoided, because it impedes free ventilation. The manhole and ventilating chamber are built side by side, and together constitute the ventilating shaft.

For ordinary sewer-ventilation, the manhole without a side chamber may be utilised as a ventilating shaft, or efficient ventilation can be secured by making a sufficient number of direct openings into the crown of the sewer. Manhole covers can also be utilised as ventilators by inserting an open grating into them. In cases where the sewer runs parallel with and close to the pavement, it is advisable to carry the ventilating shaft in a sloping direction to an open grating situated in the centre of the street, or to erect a ventilating pipe against the wall of an adjoining building. All these different methods of sewer-ventilation have been carried out in several places at my suggestion with respect to sewers which when first laid were not ventilated, and have been found to answer admirably. The mistake which is often made is to carry out extensive improvements of this description during the warm months of summer or autumn. At this period of the year the evolution of sewer-gases is greatest, and as it is evident that it must take some considerable time to construct a large number of ventilating shafts, great complaints are made of the foul effluvia which are discharged through the openings which are first made. All such improvements, therefore, should be carried out during the colder months of the year, when the sewers are better flushed and sewer-gases are not generated so rapidly. It should also be remembered that the foul effluvia given off by ventilators are frequently engendered by the catch-pits which are constructed below the ventilators to retain road drift, but which retain excrementitious matter as well. All such catch-pits should be done away with, and the ventilators be provided with dirt-boxes.

With regard to the number of openings, it may be

said generally that the terminals of all drains and sewers should be ventilated, and the junctions of branch sewers with main sewers. According to Rawlinson there should be not less than 18 fixed openings for ventilation, or 1 at intervals not greater than 100 yards, for each mile of main sewer. Flap valves, or other contrivances, should be provided for the outlet ends of sewers, to prevent the wind from blowing in. In some cases street gulleys, if left untrapped, could be utilised as ventilators. Indeed, the great object of ventilation is by means of numerous openings to so dilute the sewer air as to render it innocuous and imperceptible to the senses. Some ventilators will act as inlets for fresh air, and others as outlets, according to the direction of the wind. There can be no doubt that direct ventilation when properly carried out is the most efficient, and if sewers are properly constructed in the first instance and kept well flushed there should be no nuisance from the ventilators, or when nuisance is found to exist, a ventilating pipe will be found to remedy the evil.

Main sewers, liable to be affected by the rise of tides or land floods, must be abundantly ventilated, in order that the sewer air may not be forced back into the tributary sewers and drains. To provide for efficient ventilation under these circumstances, Drs. Parkes and Sanderson, in their report on the sanitary condition of Liverpool, recommended the erection of lofty shafts, with a sectional area at least half as great as that of the sewers. They condemned the ventilating shafts in use at the date of the inquiry as being too narrow, and ascertained by experiment that the Archimedean screw ventilators, with which the shafts were supplied, only aided the extractive power by 20 per cent.

(3.) *Flushing of Sewers.*—As offensive discharges of sewer-air are generally due to the formation of deposits,

careful attention to systematic flushing is highly essential. The flushing of sewers is effected by damming back the water, and removing the obstruction when a sufficient collection is made, the sudden rush clearing away any deposit that may have taken place. In addition to the arrangements for flushing, which should be provided at every manhole, there should also be a flushing chamber or syphon flush-tank at the head of each sewer and drain, such chambers being flushed either from the mains where there is a public water-supply or from water-carts. If the flushing is carried out from the mains, care should be taken that there is no intimate connection between these and the sewers. Sewers in straight lines, and even gradients from manhole to manhole, can be cleared out by using scrubbers.

No water from manufactories of an elevated temperature should be allowed to enter sewers before being cooled, because it accelerates putrefactive changes in the sewage. Blowing off steam from boilers into them is also objectionable.

With a system of sewerage properly constructed, well ventilated, and regularly flushed, the dangers arising from atmospheric pollution by sewer-gases is reduced to a minimum. Indeed, the amount of impurities in sewer-air under these conditions is so small as to be almost inappreciable to the sense of smell; and it may be laid down as a rule that whenever foul effluvia are given off, it is an indication that the sewer is insufficiently ventilated, imperfectly flushed, or that it has been badly constructed in the first instance. In exceptional cases charcoal may be used, but it is wrong in principle, as it cannot deodorise sewer-gas without impeding the ventilation. Formerly the practice of employing it in ventilating shafts was general, but all who have practical experience in the matter are now agreed that direct open ventilation is the

cheapest and most effectual method, and that when properly carried out it does not give rise to nuisance. It cannot be too strongly urged that the evil of a foul-smelling sewer should be dealt with at its source. If a sewer is old, leaky, or otherwise so imperfect from original faulty construction as to be nothing but an elongated cesspool, the sooner that it is abolished the better. Unfortunately, however, sewers of this description exist in almost every town; and not only so, but the gravest errors have been perpetrated in laying down house-drains in total ignorance of sound sanitary principles, and with the grossest carelessness as regards workmanship.

(4.) *Shone's Pneumatic System.*—Some mention ought to be made here of this system, which was first brought to notice at the meeting of the Sanitary Institute of Great Britain at Stafford in 1878, and has since then received a large and increasing share of attention. It has passed the stage of experiment, and there can be little doubt that it will greatly assist engineers in overcoming many of the difficulties with which they have hitherto had to contend, more especially in low-lying and undulating districts, and sea-board towns. By means of *sewage ejectors*, which are worked by compressed air conveyed in pipes from a central station, where the engine-power may be either steam or water, Mr. Shone proposes to force the sewage along properly-constructed pipes, or sealed sewers as he calls them, to the outlet, or over rising ground. The ordinary gravitating sewers, properly ventilated, and kept properly flushed, are made to discharge into one or more collecting stations according to the size and contour of the town; and in these stations are placed the ejectors. So soon as the sewage is forced into the sealed mains from the ejectors, all communication, both with the street and house-sewers, as well as with the atmosphere of the town, is completely severed, and the sewage is harmlessly

and rapidly hurried on to the outlet. Flat stagnant sewers and deep cuttings may thus be avoided, and pumping in many instances may be dispensed with. The system has been in operation for some time at Eastbourne, where it has worked to the entire satisfaction of the Local Board, and it has also been adopted for Warrington, Worthing, and Winchester. It is applicable to mansions and large public buildings as well as to towns, and has recently been applied to the drainage of the West London District Schools. There is no doubt that the system possesses many advantages, and it has been so highly spoken of by eminent engineers that its application for the removal of existing defects in the sewerage of towns, as well as to new systems of sewerage, will become much more general as it becomes better known.

2. *Traps.*—That too much reliance has been placed by engineers and builders on the efficacy of traps for the exclusion of sewer-air, is becoming every day more and more evident. Up till quite recently no adequate provision was made for drain or sewer ventilation, and the consequence was that mechanical ingenuity became taxed to the uttermost to prevent the pent-up sewer-gases from forcing their way through the terminals of drains which for the most part were situated inside houses. When hot water is poured down a drain, or when a sewer becomes suddenly charged with a large volume of water, as after a heavy fall of rain, the forces which are brought to bear within the sewer are far greater than the resisting power of any trap, and the displaced gases make their escape often at points where they are the most dangerous. There are few traps whose resisting power exceeds that of a column of water an inch and a half in height; indeed, the greater number of them, as, for example, common bell-traps, have only a resisting power of about one-quarter of an inch. Besides, it should be remembered that the

water in an otherwise very efficient trap will absorb sewer-gas on one side and discharge it but little changed on the other. All traps, therefore, should be regarded as at the best useful auxiliaries only, for in no case will they afford protection against the escape of foul air if proper ventilation be neglected. Some traps, such as the common bell-trap, are worse than useless, because they are readily removed, often forgotten to be replaced, and are easily broken. Many traps, too, and especially those which are supposed to protect the terminals of drains in cellars or basements, are practically useless, because the water in them speedily evaporates and is seldom renewed.

Although there is almost an infinite variety of traps, the most useful of them are either of what is called the mid-feather description, or are constructed on the syphon principle. Flap-traps are sometimes used for sewers or large drains, but they are merely hinged valves which permit water to flow in one direction only, and are also intended to prevent the reflux of sewer-air. In the ball-trap, a floating ball is lifted up when the water rises, and when it reaches a certain level the ball impinges on and closes an orifice.

All traps constructed on the mid-feather principle have one or more partitions dipping down into the water between the entrance and discharge-pipe; and as water stands in the trap to the height of the discharge-pipe, the partition is always under water. What are called D-traps are of this description, and the common bell-trap, with its various modifications, belongs to the same category. The following are illustrations of useful traps.

Fig. 15 is an illustration of a mud-intercepting trap, manufactured by Doulton and Co., and by means of the bucket-handle inside is easily cleaned out. Syphon traps may be described as curved tubes, in which the whole of the curve should be always full of water. All bath and

lavatory pipes should be trapped in this way, even when they do discharge on to outside gratings, to prevent the entrance of cold air. Fig. 17 is an illustration of the

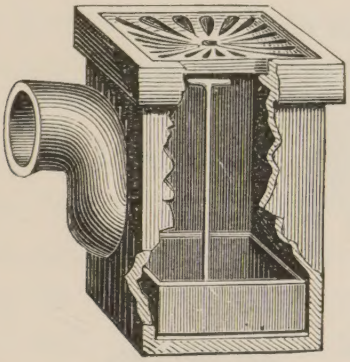

Fig. 15.

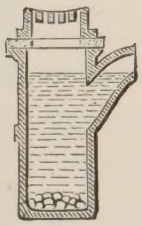

Fig. 16.—Simple Gulley Trap.

syphon trap recommended in the Annotated Model By-Laws of the Local Government Board for ventilating and disconnecting house-drains.

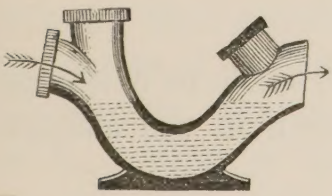

Fig. 17.

Amongst good ventilating traps, well adapted for house-drains, may be mentioned Doulton and Co.'s syphon ventilating trap, Banner's patent house-drain trap, Buchan's patent disconnecting and ventilating drain trap, and the trap known as "The patent Edinburgh air-chambered sewer trap," manufactured by Messrs. Potts and Co. of Birmingham. By adopting one or other of these appliances, the most serious defects connected with house-drainage may be effectually removed, provided the drains are well enough laid, in the first instance, to prevent leakage.

Fig. 18 is an illustration of Gregen's patent air-inlet, manufactured by Doulton and Co., together with trap and ventilating pipe. The raised rim round the shaft prevents the entrance of any dirt into the drain, and the whole apparatus if properly applied will not only effectually disconnect the drains of any house from the

sewer, but will ensure a constant current of fresh air through them. At the same time all waste-pipes from sinks, lavatories, or baths, and overflow pipes from

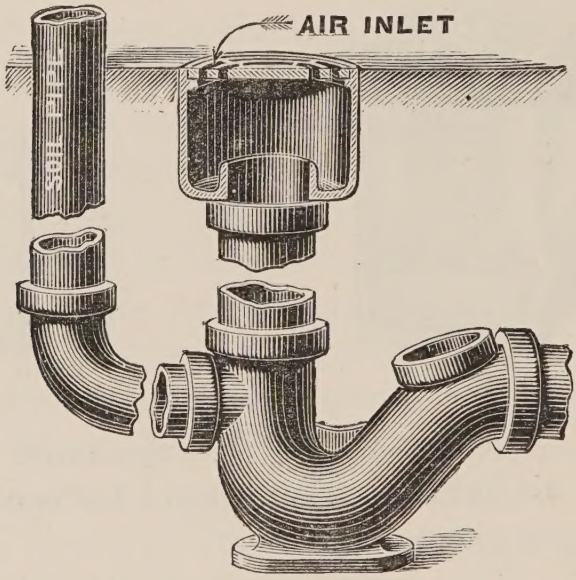

Fig. 18.

cisterns, should be carried outside, and made to discharge on trapped gratings, as previously shown in the chapter on Dwellings.

3. *Water-Closets.*—The situation, construction, and general arrangement of the water-closets best suited for private houses have already been described in the chapter on Dwellings. In the crowded districts of large towns, however, the ordinary form of water-closets has proved a failure, partly on account of the complicated character of the contrivances for flushing, but chiefly on account of the carelessness and filthy habits of the poorer classes. For these reasons some special modifications of the usual plan of closet, suited for large collections of people, and whose management may be more under the control of the public authorities, have been devised and introduced into several large towns. The arrangements which at one time found favour were the trough-closets in use at

Liverpool, the tumbler-closets in use at Leeds and Birkenhead, and what is known as the "Bristol Eject," in use at Bristol. But the best appliances of this description are latrines such as those manufactured by Wilcox and Co. of Leeds, which have self-acting flushing arrangements which sweep out the whole of the excreta at regulated intervals.

There is a special advantage, common to all closets of the trough system, which may here be pointed out. In the event of an epidemic of cholera or enteric fever raging in the crowded courts where these closets are in use, it will be an easy matter to throw disinfectants into the troughs, and thus destroy the infectious power of the alvine discharges.

The system of intercepting the solids and allowing the liquid part of the sewage to run off into the drains, has been advocated by many, on the grounds that the manure thus collected can be readily utilised, that there is no risk of clogging up the sewers, and that the sewers themselves may be constructed of much smaller dimensions. Many of the *fosses permanentes* and *fosses mobiles* on the Continent are constructed on this principle, and in this country a tank has been introduced by Mr. Chesshire of Birmingham; but it is very doubtful whether this or any other plan which merely intercepts the solids, can ever be commended for extensive use. For, on the one hand, the prevention of the more solid portion of the excrement from entering the drains does not materially lighten the sewage-problem; and, on the other, the detention of filth on premises, even though it be in close boxes, is wrong in principle, and cannot be regarded as free from danger. Indeed, the advantage above all others which attaches to the water-closet system when efficiently carried out, is the continuous and complete removal of all excremental matters from dwellings.

4. *Urinals.* — These should be lined with glazed stoneware tiles, or enamelled slabs of smooth slate. They can be kept perfectly clean and inodorous by allowing a small quantity of water to trickle down them constantly.

In all towns of any size it is a great desideratum on the score of cleanliness, health, and convenience, to provide public lavatories in suitable localities, supplied with water-closets, urinals, and washhand basins,—and they should be provided for the female as well as for the male sex. At Nottingham a ladies' lavatory has recently been provided by the Corporation, which about pays for interest on outlay and attendance, and in Glasgow three such lavatories have also lately been opened.

Section II.—The Privy or Midden System.

From what has already been said, it is obvious that the privy or midden system of old type, with leaky and fœtid cesspits behind, is totally inapplicable to populous places. Cesspools and large deep ashpits in connection with privies are equally objectionable, no matter what precautions be taken. To improve the system so as to render it even tolerable, it is essential that the pit should be small in order to secure frequent removal of the contents; that it should be shallow and perfectly water-tight to prevent leakage; that it should be roofed in, to keep out rain; that it should be well ventilated; that it should be easy of access; that it should be at a safe distance from the house; and that the contents should be kept dry and inoffensive by means of sifted ashes or other dry refuse. It is not necessary that it should be drained, for if the ashes do not keep the excreta dry the system is a failure. According to Mr. Netten Radcliffe, the only kinds of midden-privies which were found to answer all these requirements fairly well were the improved middensteads of

Hull and Glasgow. The *Hull middenstead* consists solely of the space under the closet seat, and its floor is formed by a flag which slopes downwards to the back wall at the ground-level there. The ashes are thrown in through the hole in the seat, and the front board of the seat is movable, to enable the scavenger to get at the contents, which are removed weekly. Privies of this description can be built for about £3. The *Glasgow middenstead* is proportionately of smaller size than the Hull middenstead, but is extended sufficiently far back from the seat to admit of the ashes being thrown upon the excrement from behind. As several families use one privy, the contents are cleared away every two days.

Other schemes, intended to diminish the offensiveness of large middensteads, as observed in Manchester, Salford, Nottingham, and elsewhere, were all found to have practically failed. In Manchester, where many of them were drained into the sewers, it was discovered that the sewers were becoming gradually choked up with sediment. There is no doubt that in towns where the water-closet is not universally adopted, the only safe alternative is some form of the pail or dry closet.

Section III.—The Pail System.

The more common varieties of this system are the following:—

1. Pails used without preparation (Glasgow).
2. Pails supplied with a deodorant and antiseptic (Rochdale, Birmingham, Nottingham, Leeds).
3. Pails lined on the Goux system (Halifax).
4. Pails in which ashes and house-refuse as well as excrement are deposited (Edinburgh, Nottingham).
5. Pails into which coal ashes are screened above the excrement (Manchester, Salford, Cockermouth).

In order to carry out this system in the most efficient manner, two pails are required for each closet, one to receive the excreta, and the other the ashes and house-refuse. The excrement pail may be either a wooden pail or tub, as used at Rochdale, Nottingham, and Halifax; or it may be of metal, such as that used in Manchester, Leeds, and Glasgow. In either case it is requisite that it should be round, so that it can be easily cleaned, and as regards capacity and convenience for removal, its cubic contents should not exceed 10 gallons. If of wood it should be tarred or creosoted, and if of metal it should be made of galvanised iron. All pails should be provided with tight-fitting lids, such as Haresceugh's excreta pail with patent spring lid, or Kirk's patent, so that they can be carted away without creating nuisance. When one pail is removed, another, which has been thoroughly cleaned after having been emptied at the depôt, should be left in its stead.

The ash pail should be somewhat larger than the excrement pail, and may be either a rectangular box of handy dimensions, a tub, or a galvanised iron pail.

In the Goux system as carried out at Halifax, the tubs are lined with some dry absorbent material, such as chaff, straw, shoddy fluff, hay, dry ferns, or any kind of animal and vegetable matter which is useless for other purposes. The patentees direct that these materials are to be mixed in such proportions as may be most convenient, together with a small percentage of sulphate of iron or sulphate of lime. The materials are pressed close to the bottom and sides of the tub by means of a mould, which is afterwards withdrawn. A separate bin must be used for the ashes and house-refuse; but urine may be emptied into the tub, and is supposed to be absorbed by the lining, the excreta remaining tolerably dry. The tub is removed once once or twice a week, according to circumstances.

When these closets are well managed, they are clean and inoffensive, and the system generally has been favourably reported on by Mr. Haviland of Northampton, and Mr. Syson of Huntingdon, as well as by Mr. Netten Radcliffe. On the other hand, it has been asserted that the material used for packing generates swarms of minute flies; and that, in other respects, the system, as it is usually carried out, is not free from nuisance. Although there is perhaps too much importance attached to the absorbent power of the packing material, there can be no doubt that the advantages of the Goux system, when compared with the midden system, cannot well be overrated. When properly managed there is less offensiveness than with the ordinary pail system, while the resulting manure is much more easily dealt with, and, it is said, commands a readier sale than ordinary pail closet manure mixed with ashes.

In Manchester, Salford, and other large towns, a dry ash system of excrement-disposal has been combined with a pail system; and in some places Morrell's patent self-acting cinder-sifting ash-closets have been extensively introduced.

As to the kind of closet best suited for the pail system, it is found that a closet somewhat after the improved Hull or Glasgow pattern, but with level floor and with space enough to contain the ash-pail as well as the excrement pail, is the cheapest and most convenient. According to Mr. Netten Radcliffe, "it would be difficult to suggest any great improvement upon the patterns adopted in Rochdale, Manchester, and Halifax. The compactness of the plan and the facility with which the pail-closet can be adapted to the varied requirements of old towns in the reconstruction of midden-closets, is most instructively shown in the plans given of adaptations in Halifax."

But in all large towns the great difficulty which has

to be encountered rests mainly on the disposal and treatment of the ashes, refuse, and pail contents after they have been collected. The following is a description of the system carried out in Warrington, and I beg here to express my indebtedness to Mr. Longdin, surveyor of that borough, for the details :—

(1.) *Ashes, etc., collected in ash-tubs.*—These are discharged at the ground-level of the depôt, and lifted by an elevator and cast into an automatic cinder-screen, which separates the material into two portions, viz. fine ash and coarser substances. The fine ash is discharged at a point sufficiently high that it can be shot into a cart without labour, and afterwards removed and mixed with such portion of the pail-contents as will furnish a manure sufficient to satisfy the local demand. The coarser materials are discharged into the top of a furnace called a "Destructor," which is almost self-feeding, and all that is required is to break up and remove the clinkers. The heat generated in the process of combustion passes under and through a multitubular boiler, and generates steam for furnishing the power required for working the whole machinery. The clinkers from the "Destructor" are passed into a mortar-mill, which reduces them to powder, and this is either sold as sand or mixed with lime to form an excellent and tenacious mortar.

(2.) *Street sweepings, including vegetable and animal refuse.*—This refuse, which consists mainly of sweepings from the markets and streets, is discharged on the ground-level, and raised by an elevator to a platform, and thence passed into a furnace called a "Carboniser," which converts all vegetable material into charcoal. The fuel required for heating this furnace consists of a portion of the sifted cinders from the ash-tubs. The charcoal produced is a powerful deodorant, and what is not used for mixing with the pail-contents is sold at 20s. per ton.

(3.) *Pail-contents.*—The bulk of these, which have not been mixed with fine ashes or charcoal, are emptied on the ground-level into a covered tank, and are conveyed by means of a chain-pump into an elevated air-tight store-tank. After having been mixed with a small portion of acid to fix the ammonia, the thicker portion of the material settles to the bottom of the tank. The more liquid contents are drawn off into two "Evaporators," which are tall cast-iron cylinders, each containing near its lower end a drum-shaped heater, precisely resembling a multitubular steam-boiler. These cylinders are partially filled, and the heating-drums are covered with the thin liquid; steam is introduced into the heating-drums, and the liquid becomes partially concentrated. When the contents have lost by evaporation the greater portion of their water they are drawn off into a machine called a "Firman's Dryer," along with the thick portions of the pail-contents which have settled in the store-tank. This machine consists of a steam-jacketed horizontal cylinder, traversed by a steam-heated axis and by steam-heated revolving arms, and furnished with scrapers to keep the inner surface of the cylinder free from accumulations of dried excreta. The pail-contents are admitted into the "Dryer" at the consistency of thin mud, and after treatment this mud emerges as a dry powder resembling guano in appearance and quality.

The method of working this important mode of concentration is thus summarised:—"The vertical concentrating vessel first described is supplied with steam direct from the boiler, and the 'Firman's Dryer' is supplied in like manner. The steam and vapour, however, which are driven off from the concentrating vessel and the 'Dryer,' instead of being allowed to escape into the air or being condensed by cold water, are used to furnish heat to the large or main concentrating apparatus, which is kept

boiling at a low temperature. This is effected by conducting the boiling below atmospheric pressure in a vacuum which is maintained by an air-pump attached to the steam-engine. This larger vessel is in fact a vacuum pan. The apparatus is so connected with tubes and valves that the 'Firman's Dryer' may also be worked under vacuum if necessary. The whole of the vessels are enclosed. All the steam generated is condensed, and the odour given off during the process is also passed through the 'Destructor' fire and destroyed. From the time the liquid material enters the store-tank there is no opportunity for odour to escape into the air, as it is kept closely under cover until it finally emerges as a dry powder. The manure made by this process closely resembles guano in appearance and quality, and is sold at £6 : 10s. per ton at works."

After the pails are emptied they are thoroughly cleansed and disinfected.

The operations at the depôt are conducted without the purchase of any coal, and they are so arranged that in case of any interruption to the new process the old can be continued efficiently and with much less cost than formerly.

This process of purification by fire, as it is called, has also been adopted by Birmingham, Leeds, Rochdale, Manchester, and other towns; and so far it appears to have solved the difficulty of dealing satisfactorily with such refuse of towns as is not disposed of by means of the sewers.

The "Destructor" and "Carboniser" have both been devised by Mr. Fryer, of the firm of Manlove, Alliott, Fryer, and Co., engineers, Nottingham; while Firman's patent "Dryer" is also supplied by the same company.

The whole of this process is fully described and discussed in an excellent report on the "Disposal of Refuse,"

by Dr. Sedgwick Saunders, Medical Officer of Health to the City of London, published in 1881. In this report Dr. Saunders further recommends that condemned butcher-meat and carcases, after being crushed in a mill called a "Devil," should be treated in a Firman's Drying Apparatus, which separates the fat, and reduces the bone and other tissues to a fine fertilising powder. Whether in desiccating liquid excreta or other foul refuse, the great advantage attaching to this process is that it can be carried on without creating any nuisance.

Section IV.—The Dry System.

The difference between what is called the dry system of excretal removal and the pail system depends upon the deodorising and destroying power of the dried earth or other material, which, if used in sufficient quantity, converts the mixture into a uniform and inoffensive mass.

Moule's Earth-closet.—This consists of a wooden box with a receptacle or pail beneath, a reservoir for the dry earth above, and an apparatus for measuring and delivering the requisite quantity of earth whenever the closet is used. The closet is made self-acting by means of a spring in connection with the seat, or it is worked by a handle as in the ordinary water-closet. It is essential that the earth be previously dried and sifted, that a sufficient quantity be thrown into the pail before the closet is used, and that the same amount be delivered over each particular stool. The quantity requisite for the deodorisation of each stool (inclusive of the urine) is found to be $1\frac{1}{2}$ lb. The slops and the rest of the urine must be removed in some other way.

This system has been introduced, with more or less success, into several public establishments and villages

throughout the country, but it is altogether unsuited for the requirements of large towns.

When the closets are properly managed, it appears that the fæcal matters are disintegrated, so that after a time no excrement whatever can be detected in the mixture. After keeping and drying, therefore, it may be used several times without losing its deodorising and absorbing properties, but much depends on the quality of the earth used at the outset. The suitability of various soils is given in the following order:—1, rich garden mould; 2, peaty soils; 3, black cotton soils; 4, clays; 5, stiff clayey loams; 6, red ferruginous loams; 7, sandy loams; 8, sands.

For isolated buildings and small country villages, where there is no difficulty in obtaining suitable earth, and afterwards disposing of it, and where the necessary labour and management can be procured, the system is almost perfect.

The closets may either be used as fixtures or as movable commodes, the latter being intended for use in bedrooms, hospital-wards, etc.

The other dry closets which have been specially commended are those known as the Moser closet, and the closets manufactured by Heap and Co.

Although other appliances might be enumerated in connection with the dry system, it will be sufficient to point out that without proper care and supervision this system possesses no special advantages over the ordinary pail system.

With respect to the various systems already referred to, the Committee on Sewage Disposal reported that "the attempts to economise in town-sewering and scavenging by removing human excreta separately has been a failure, the local costs have been increased, and the local nuisances also, in proportion to the time of retention of the excreta

before removal; there is also the inconvenience suffered by trespass on the privacy of the household."

Section V.—Lieurnur's and other Continental Systems.

These need only require brief mention. Captain Lieurnur's system may be described as consisting of air-tight iron tanks situated under the streets, which are connected by iron pipes with the closets in the houses. By means of a powerful air-pump worked by steam the sewage is sucked along the pipes to these central tanks, and is afterwards converted into *poudrette*. Only a little water is used in the closets. The system has been tried in Amsterdam, Leyden, and elsewhere; but, owing in great measure to its original cost, it has not met with much acceptance. Moreover, it appears to be radically defective in principle, because it is evident that the pipes must become clogged up sooner or later with fæcal matter, and indeed this result is not at all unusual. According to the Seventh Report of the State Board of Health of Massachusetts, there is great complaint of the bad odour from the closets when they are situated inside houses, and in order to obviate this nuisance the people are in the habit of flushing them with large quantities of water. The consequence is that the sewage becomes so much diluted that it could only be converted into *poudrette* at a most ruinous cost.

The *fosses permanentes* of Paris, Brussels, and other continental towns are huge pits, placed generally under courtyards. They are lined with cement, so as to render them impervious, and are usually ventilated by shafts rising some feet above the roofs of the houses. The contents are removed three or four times during the course of the year by air-tight carts (*tonneaux*), from which the

air is exhausted previous to filling, so that the sewage is forced into them through a hose by atmospheric pressure. The closets in connection with the cesspools are almost invariably in a filthy state, from the habit of standing on the seat, which appears to be prevalent in private houses as well as in public places.

The system known as *fosses mobiles* is now adopted in many continental towns, and is a great improvement on the system of *fosses permanentes*. The *fosse mobile* is a closed tub placed on a stand with wheels, and connected by a descent-pipe with the different closets or *faïences* of a house. When filled it is replaced by another of the same construction. The *abfuhrtonnen* of the Germans are of a similar description, but in many of the larger towns the bucket or pail under the privy seat is used (Berlin, Leipsic, etc.)

Section VI.—Systems best suited for Rural Districts.

In villages where the scavenging is undertaken by the Sanitary Authority, it is just as essential that some uniform scheme of excrement-disposal should be adopted as in towns; but in the great majority of country villages provided with sufficient garden space, public scavenging is not necessary, because the solid refuse can generally be safely disposed of on the premises. The kind of alterations, therefore, which may be required to remove privy nuisance, will depend very much upon existing arrangements. If, for example, the privy abuts against the house, or is not very far from a well, it should either be removed altogether, or be converted into an earth or ash closet, and be provided with a box or pail to receive the excreta. "Inside a house," as I have said elsewhere, "the only kind of closet which can be used without risk to health

must be a water-closet communicating with a drain or cesspool, or a dry closet of an approved pattern; but in either case the closet must be detached from any living or sleeping room, and be properly ventilated. In country villages, however, the closet accommodation, except in a few of the better-class houses, is situated outside, and is of every conceivable description. In the older villages it is sometimes represented by a rough wooden erection, with a hole dug in the ground to receive the excreta; or more frequently by a sentry-box looking structure, stuck somewhere near the far end of the garden, and with a stinking leaky cesspit behind. In more modern villages, however, the privy and ashpit or middenstead are found combined; but as a rule the ashpit is large and deep, leaky and uncovered, so that at all times it is more or less of a nuisance. Then, again, in the few best-class houses provided with water-closets, it is generally found that the soil-pipe is not ventilated, and that the closet discharges either into a covered cesspool, from which any gases generated can escape only into the house, or into a village-drain which was not constructed to receive excremental filth. Such, briefly, are some of the more common varieties of closet-accommodation to be met with in country villages, and I need hardly say that the structural defects connected with them are very often a source of nuisance and risk to health. How, then, are these defects to be remedied, legally, in the first place, and with a due regard at all times to efficiency and cost? Take, for example, the primitive wooden structure, with the hole dug in the ground to receive the excreta. As a rule, this kind of privy-accommodation is only met with when the cottage itself is old and dilapidated, so that it would be a sheer waste of money to insist on the erection of a new and substantial structure. All that the law demands is to fairly satisfy the requirements of health and decency, and

this can be accomplished in the great majority of instances at a very trifling outlay. Let the hole be cleaned out and filled in with fresh gravel or clay, and covered either with cement or bricks set in cement, and such other alterations made that a galvanised iron pail or box can be readily inserted beneath the seat to receive the excreta. This, of course, should be regularly emptied into the garden; and to obviate nuisance, dry earth or sifted ashes should be thrown into the pail at least once a day, and in sufficient quantity to keep the excreta covered. If the seat is hinged, there will be no difficulty in removing the pail or in throwing the ashes into it without dirtying the seat. Or take the old-fashioned privy, with its fœtid cesspit behind. This can be readily converted into an inoffensive privy and ashpit combined, by filling up the cesspit to the level of the ground; paving or cementing the filled area, walling it in, and covering it as an ashpit; raising the floor of the privy a step, and with it the seat; and placing a flag sloping backwards beneath the seat, so that the excreta may be readily covered with the sifted ashes or dry refuse thrown into the ashpit. Or the ashpit may be dispensed with, and, after filling up the cesspit, the privy may be readily converted into a pail-closet. To sift the ashes, either a common riddle may be used, or some kind of cinder-sifter. But whatever alterations may be adopted in addition to those required for privacy and ventilation, the great desideratum is to keep the excreta dry, and prevent undue accumulation. Large, deep, and uncovered middensteads, or ashpits connected with privies, are always a source of nuisance. When they are nearly empty, the surrounding soil drains into them in wet weather, so that for the time being they become open offensive cesspools, and when full they permit of soakage into the surrounding soil. Every ashpit, therefore, connected with a privy should be little, if at all

below the level of the ground; it should be cemented, or made otherwise water-tight, and should be covered (a sloping tarred wooden covering hooked on to the back of the privy will do), to keep out the rain. Moreover, it should be of limited capacity, to prevent undue accumulation, and thereby necessitate frequent removal of the contents. Sometimes, in order to keep the contents more or less dry, the ashpit is drained; but apart from the liability to chokage of the drain, and the nuisance arising from the admission of liquid excremental filth, drainage of the ashpit should be prohibited, because, if the ashes do not keep the excreta dry and inoffensive, the system is a failure."

From these few remarks it will be observed that I advocate every possible latitude as regards the way in which nuisances connected with privy accommodation may be removed. In villages, however, for which public scavenging is considered necessary, there is no doubt that some uniformity in the nature of the alterations must be carried out, and I am of opinion that one or other of the pail systems would answer best. In rural districts, provided with urban powers, the kind of closet-accommodation supplied for new houses should be carefully considered and enforced. If the closet adjoins the house, it should be a pail or dry closet, and if it be at some distance, and sufficiently far removed from the well, a properly constructed privy and ashpit may be allowed.

Section VII.—Disposal of Slops.

The term slop-water, as commonly understood, is used to indicate ordinary household liquid refuse exclusive of fæcal matter. For the most part it consists of urine, soap-suds, and the foul-washings from premises generally; and though it may not be considered as

offensive as town-sewage, it frequently gives rise to serious nuisance when it is allowed to fester in rubble drains or stagnant ditches, and is a constant cause of well-pollution in country districts. In all sewered towns the slops are of course removed by the ordinary drains and sewers, and even in most villages it is found that their disposal is in great measure a question of village-drainage in the first instance. But, unfortunately, this village-drainage is so radically defective in the great majority of instances, that pollution of air and water are alike common. The shallow road-drains which were intended, when first laid down, to carry off the surface water, and which, for the most part, are generally constructed of common drain-pipes, or loosely laid bricks or stones, have been converted into common sewers by conveying into them the badly laid and open-jointed drains leading from almost every house or group of houses in the village. If there be a water-course near the village the drainage discharges into the stream by one or several outlets, as the case may be, and with what results it is needless to specify. Should it happen, however, that the village is some distance from a stream, then it is found that the slops discharge into open ditches by the roadside, or into field-ditches in the immediate neighbourhood of houses, and thereby often give rise to filthy nuisances in every direction. This description, it is true, only applies to the worst drained villages; but in almost all of them some of these defects are to be met with. Shallow, unevenly laid, and leaky drains are especially common; and as these are not only liable to pollute any wells which may be near them, but in consequence of the want of proper means of flushing permit of filth-accumulations, which give off noxious effluvia, they are a source of constant danger.

And this description, it should be remembered, ap-

plies to villages in which water-closets do not exist at all, or are very rare, so that the whole of the nuisance may be said to depend upon the disposal of the slop-water. The question, therefore, at once arises whether in any given case a new system of drainage will be required, or the existing system improved to remove nuisance, or whether the slops cannot be satisfactorily disposed of in some other way. If common gutters, as some recommend, are to take the place of drains, it is clear that all the old defective drains must first be taken up and filled in with sound material, and that the gutters themselves should be properly channelled and kept clean. But in the present condition of village roads, with badly-laid side-paths, it is just as evident that these open gutters would be a constant source of nuisance, and hence, in compact villages, or villages of any size, the question of the disposal of slops, is, as I have already said, a question of drainage, and need not be further discussed here. It is sufficient to state that all such drains ought to be well laid, well ventilated, and kept properly flushed, especially in warm weather, by means of a hand water-cart, which could be easily wheeled about by the road-man. (For further remarks, see next chapter.)

As regards scattered houses, or groups of houses which create nuisance by draining into open roadside ditches, such nuisance may be obviated by using the slops in the garden, or, if there is no risk of water-pollution, by covering in the ditch for some distance. Where there is sufficient garden space, and the ground slopes away from the house, the most satisfactory way of treating them is by sub-irrigation, and the use of Field's syphon flush-tank, but care must be taken that the sub-irrigation drains are laid at a safe distance from the well. Sometimes the drains lead into what is called a dumb-well; and provided there is no well for drinking-water

near, and the dumb-well is ventilated and regularly cleaned out, this may be regarded as a tolerably safe and ready method of dealing with the difficulty. But the multiplication of dumb-wells or cesspools in villages, as in towns, is always attended with danger, and ought to be avoided as much as possible.

Section VIII.—Public Scavenging.

Except it be in small scattered communities, and perhaps purely agricultural villages, it may be laid down as a rule that no semblance of local cleanliness can be maintained unless the scavenging, as well as the sewerage, be undertaken by the Sanitary Authorities; for, in proportion as dwellings become aggregated, and populations increase, it becomes more and more difficult for individual householders to dispose of their refuse separately. Fortunately, in the great majority of agricultural villages there is sufficient garden space attached to the houses to permit at all events of the safe disposal of the solid refuse on the premises without creating nuisance, or for exceptional cases there need be little difficulty in arranging for its disposal on some closely adjacent land. Arrangements, for example, may generally be made with some neighbouring farmer, or, as Mr. Haviland has suggested, any exceptional difficulties which may arise from want of sufficient garden space might be overcome if Sanitary Authorities were to provide a spare corner of ground, known as "the muck acre," to which householders could remove their solid refuse. But whenever, in any village or town, these difficulties are ascertained to be at all common, it then becomes the duty of the Sanitary Authority of the district to undertake the efficient scavenging of premises, either through their own officers or by contract; and in case of refusal or neglect, they can be compelled to do so

by order of the Local Government Board. In any case, however, the Sanitary Authority is virtually responsible for the cleanliness of its district, either by enforcing the provisions of the Public Health Act for the prevention of nuisance arising from filth-accumulation on individual premises in places to which scavenging does not extend, or by systematically preventing the occurrence of nuisance in places where public scavenging has been introduced.

As regards the general details of public scavenging much will depend upon local circumstances, and upon the method of excretal removal which may be found to prevail in any particular town. Where the old-fashioned midden system is still allowed to be carried on, the house-refuse is mixed with the excreta, and both are carted away together. In the majority of towns, however, the ashes and other solid house-refuse must be collected and removed by a separate system, which necessitates the use of dust-pails or bins, and the daily or frequent visit of the scavenger's cart. For dwellings occupied by single families the dust-box or pail answers very well, it being large enough to contain the dry refuse collected during the twenty-four hours; and as it is emptied into the scavenger's cart at a stated time daily, any accumulation about the premises is prevented. But in crowded parts, where families live in separate tenements, the whole of the ashes and dry refuse is usually, in the first instance, emptied into a common dust-bin, and afterwards carted away when the bin becomes full. In this case it is necessary that the bin should be roofed in, in order to keep the contents dry, and that it should be well ventilated. No slops or excrement should be allowed to be thrown into it, because the former excite fermentation in the vegetable and animal matters contained in the refuse, and the latter renders the contents offensive. It need

scarcely be added that, in a sanitary point of view, dust-bins should be frequently and regularly emptied.

In scavenging old-fashioned midden-steads and privies, the nuisance is so abominable that the soil-cart can only make its rounds during the night-time, and even then the stench is so horrible that the air of every street or court along which the cart passes becomes for the time being positively dangerous to breathe. People who are out late at night may sniff these carts a long way off, and when they do so they generally beat a hasty retreat.

One very important branch of scavenging in urban districts is directed to the cleaning of streets and back courts, many of which are so badly constructed that it is next to impossible to prevent filth-accumulations. Gutters are often so unevenly laid, that after rain or flushing there are small stagnant pools to be seen throughout their whole extent. The surfaces of macadamised streets, again, are being constantly pulverised, and give off clouds of dust containing large quantities of decomposing animal and vegetable matter in dry weather, or are covered with liquid mud when it is wet; while paved streets present numerous interstices, which cannot be efficiently cleaned out even when scrubbing-machines and flushing are both used. There is no doubt, therefore, that the new plan of street construction which has lately been introduced into some parts of London and other large towns, whether it be wood-pavement or asphalt, and preferably the former, will not only prove to be economical in many ways, but will also be productive of great sanitary advantages. Tar-asphalt, if properly laid, is especially applicable to side paths, back courts, and narrow streets, where the traffic is inconsiderable, because it is cheap, durable, non-absorbent, and washable.

CHAPTER XII.

PURIFICATION AND UTILISATION OF SEWAGE

It has already been shown, in the previous chapter, that of all methods of sewage-removal, the water-carriage system is the one which best meets the requirements of large towns. It is the speediest, cleanest, and, in the long run, the most economical, method which can be employed on an extensive scale, and its general sanitary advantages are now placed beyond dispute. But no sooner had this difficult hygienic problem been solved by engineering skill than another of even greater difficulty arose. The eagerness of early sanitary reformers to get rid of human refuse at any cost blinded them to the fact that, by pouring sewage into the nearest watercourse, they were merely removing the evil from one place to take effect somewhere else. No consideration was paid to the probable results of the method on the future water-supply of increasing populations, nor to other serious consequences which speedily began to declare themselves. Rivers were in reality converted into sewers, and the communities down stream, while they loudly complained of the annoyance and danger to health, added to the nuisance by following the general example. After a time it was discovered that the mouths of navigable rivers were being silted up, that valuable stocks of fish were destroyed, that water-supplies were contaminated, and that riparian rights were in every sense grossly violated. Such were some of the more important evils

resulting from river-pollution, and eventually legal prohibitions were issued in many places to prevent their continuance. These prohibitions have multiplied, until the sanitary authorities throughout the country are at last compelled to purify the sewage of towns before it is discharged into any watercourse at a distance from the sea, or run the risk of incurring legal penalties; while the Rivers Pollution Act of 1876 absolutely prohibits any new drainage-works which may in future be carried out from discharging into any river or stream without previous purification.

Meanwhile there has been an increasing number of economists who have rightly maintained that sewage was not only wasted, but worse than wasted, when discharged into rivers, and that, on account of its manurial value, its proper destination was the soil. Hence has risen the larger question of the utilisation of sewage, the merits of which will be best understood by considering first the composition of town-sewage.

Section I.—Town-Sewage.

In addition to excretal matters, town sewage contains the effete products of various trades and manufactures, animal and vegetable *débris*, mineral detritus from roads and streets, and the like, all of which are held in suspension or solution by an amount of water varying according to the water-supply in the first instance, and depending, in the second place, on the rainfall and amount of subsoil-water entering the sewers at different times of the year. This varying amount of water is one of the chief difficulties to be encountered in the utilisation of sewage, and, apart from other considerations, it has led engineers to recommend the introduction of the pipe-sewer system, which has already been described, into all towns where sewerage-plans have yet to be carried out. The sewage,

delivered from pipe-sewers, consisting almost exclusively of excretal matters, slops, and the water supply, can of course be readily estimated in all cases, and is much more easily dealt with. But with common drain-sewers, which receive in addition the rainfall and subsoil-water, not only is the extent of dilution much greater, but it is constantly varying in amount. Thus, to quote the data given in the Third Report of the Sewage of Towns Commissioners (1865), it is considered that 60 tons per head per annum (= 36 gallons per head daily) is the average amount of normal or dry-weather sewage in the metropolis; but this amount is further increased by the rainfall and subsoil-water from two-thirds to an equal volume. With pipe-sewers, however, the amount of sewage equals the amount of water-supply, and in towns supplied on the constant system, this ought not to exceed 20 gallons per head daily, or about 33 tons per head per annum. In the face of such considerations as these, the sanitary and practical importance of Mr. F. O. Ward's famous alliterative dogma of "the rainfall to the river, and the sewage to the soil," becomes at once apparent.

But, with either system of sewers, the value of the sewage may be said to depend entirely on the excretal matters, and the amount and relative value of these will be gathered from the following data:—

The subjoined table represents, as the result of numerous analyses, the average amount and composition of excretal matter discharged by a male adult daily:—

	Fresh Excrements.	Dry Substances.	Mineral Matter.	Carbon.	Nitrogen.	Phosphates.
	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.
Fæces	4·17	1·041	0·116	0·443	0·053	0·068
Urine	46·01	1·735	0·527	0·539	0·478	0·189
Total	50·18	2·776	0·643	0·982	0·531	0·257

In a mixed population, the actual amounts per individual will obviously be considerably below this average, and, according to Dr. Parkes, they may be estimated at $2\frac{1}{2}$ oz. fæcal matter and 40 oz. urine daily,—an estimate which gives 25 tons solid fæces for every thousand inhabitants annually, and 91,250 gallons of urine. But the above table also shows that the manurial value of the urine voided in the twenty-four hours greatly exceeds that of the fæces passed in the same time. Indeed, the relative value, as determined by numerous analysts, is approximately as 6 to 1.

The actual value of both urine and fæces in sewage has been estimated at 6s. 8d. per individual per annum, supposing that 10 lbs. of ammonia is a fair estimate of the amount voided in that time. When the sewage averages 24 gallons daily per individual—that is, 40 tons per head per annum—its money value, according to this estimate, would be 2d. per ton, and the value per ton will decrease in proportion to the rate of dilution above this average. It may be added that this estimate corresponds very closely with the money value of average sewage given in the First Report of the Rivers Pollution Commissioners (1868); for it is there stated that "the value of the *dissolved* constituents in 100 tons of average sewage is about 15s., while the *suspended* matters only contain about 2s. worth of them." In other words, 100 tons are worth 17s., or about 2d. per ton. But no matter what may be considered the theoretical value of sewage in its crude state, it has long since become a question of least cost as regards its disposal.

Section II.—Schemes for the Purification and Utilisation of Sewage.

These have generally been classified under the separate headings of precipitation, filtration, and irrigation processes, and the more important of them which have been tried or are still in operation are as follows :—

1. *Precipitation processes.*—In all of these processes the main object in view is the purification of sewage by the introduction of chemical agents. The dissolved matters are precipitated to a greater or less extent, and can therefore be separated along with the suspended matters, while the effluent water is supposed to be in a sufficiently pure state to allow of its being discharged into a stream or river without producing any serious degree of pollution. It is needless to say that many of them have proved to be signal failures, chemically as well as financially. Fictitious values were given to the resulting manure, and some of the schemes which otherwise might have proved fairly successful, were simply ruined by being made stock-exchange speculations. Indeed, it cannot be too widely known that, no matter what process may be adopted, Sanitary Authorities must be prepared to pay a subsidy for the chemical treatment of their sewage, because it is now clearly established that the manure, or whatever other products may be obtained, will in no case pay, or nearly pay, for the cost of purification. Several of the following processes have been tried and failed, while others are still on trial, and they are given here rather to show what has been attempted in this direction, than as selected instances of success or failure :—

(1.) *Precipitation by Lime.*—This process was at one time carried out on an extensive scale at Blackburn, Leicester, and Tottenham. It consists in mixing the sewage at the outfall works with a certain proportion of cream of lime, when a copious precipitate takes place, which may be sold as manure or converted into bricks. The supernatant fluid flows off in a comparatively clear though milky condition, but contains about half the putrescible matter of the sewage, and a great proportion of the fertilising constituents. The plan has been pronounced by the Rivers Pollution Commissioners to be a conspicuous failure, "whether as regards the manufacture of valuable manure, or the purification of the offensive liquid."

At Northampton a modification of this process, by the addition of iron perchloride and subsequent filtration through calcined iron ore, has also been tried, but with little better results. Other salts, such as salts of zinc and manganese, and carbolates of lime and magnesia, have been proposed as adjuvants to the lime-process, but they all fail in separating the ammonia and other manuring material. They disinfect the sewage for the time being, but do not prevent subsequent decomposition.

(2.) *Blyth's process* consisted in the addition of a salt of magnesia and some lime superphosphate, or superphosphate of magnesia and lime water, with the view of purifying the sewage by the formation of the triple phosphate of magnesia, ammonia, and water. Such a precipitate, however, can only take place in water containing an excess of ammonia ; so that the whole process, while being more costly than others, was found to be as inefficient.

(3.) In *Holden's process,* a mixture of iron sulphate, lime, coal-dust, and clay, is added to the sewage, but it

fails to remove the nitrogenous matters in solution, and indeed increases their amount by dissolving some of the suspended constituents.

(4.) *Bird's process,* which was tried at Cheltenham, but abandoned, consists in the addition of crude sulphate of alumina, and subsequent filtration through coke. The sulphate of alumina was obtained by treating pulverised clay with strong sulphuric acid. In this and Stotherd's process, which somewhat resembles it, the effluent liquid was not found to be sufficiently purified for admission into a river without creating a nuisance.

(5.) *The "A B C," or Sillar's process.*—This process, which attracted so much attention some few years ago, had a prolonged trial at Leamington on an extensive scale, and was ultimately pronounced to be a failure. It consisted in adding a mixture of alum, blood, clay, charcoal, a salt of manganese, and other ingredients, to the sewage as it entered the works. A precipitate was thus obtained, which settled to the bottom of the tanks in the form of a soft black mud. This was afterwards pumped up into receptacles, from which it ran into centrifugal drying machines, or was removed into drying chambers. But in either case it was subsequently spread out on the ground to complete the drying process, and the mass was from time to time sprinkled with sulphuric acid to fix the ammonia. It would appear, from the conclusions of the Rivers Pollution Commissioners, that, though it was superior in some respects to the processes already described, it was nevertheless an inefficient purifier. It is but right to state, however, that the process has recently been much improved, and is now carried on successfully at Aylesbury.

(6.) *The Phosphate process,* as proposed by Messrs.

Forbes and Price, consists in adding to the sewage a solution of the native phosphate of alumina, dissolved in sulphuric or hydrochloric acid, and diluted in water. The resulting manure has been estimated by Dr. Voelcker at £7 : 7s. per ton. The effluent water is clarified and disinfected, but not by any means freed from putrescible or fertilising matters, and the originators of the process have themselves pointed out that it is only intended as a preliminary step to irrigation, where that can be carried out. Where irrigation is impossible, the process is completed by adding milk of lime, to precipitate the phosphates in solution. The process generally has been favourably reported on.

(7.) In *Hillé's process* the mixture consists of lime, tar, calcined magnesium chloride, and some other substance not named. The lime is slaked, and the tar added while it is hot. The whole ingredients are subsequently mixed with water, and flow through a large tap into the tank which receives the sewage. Here precipitation takes place, and the sewage, completely deodorised, passes into a second tank, where the deposit settles. The effluent water is afterwards filtered through a charcoal basket into a third tank, is received into a fourth, and overflows from this into a small brook. The working expenses of the process are small, but the manure is not valuable.

(8.) *General Scott's process* differs from others already described, in the introduction of the chemicals into the sewer at some considerable distance from the outfall. The precipitating agents consist of lime and clay properly pulverised, and the motion of the sewage in its onward flow ensures their thorough admixture with itself before it reaches the outfall. The resulting sludge which is formed, instead of causing any deposit in the sewer, as

some anticipated, acts rather as a scouring agent, and keeps the sewer clean. When received into the outfall tanks, the sewage is found to be deodorised, and here the suspended matters are deposited. These are subsequently removed to be dried and burnt, and are thus converted into a useful cement. The drying process, it appears, is not attended with any nuisance.

The British Association Sewage Committee have reported favourably on the whole process, as solving one of the difficulties of the sewage question, namely, the separation and deodorisation of the offensive ingredients in an efficient manner, at a comparatively small cost, and of easy application on a large scale. The effluent water, according to the Committee's analysis, contains rather more than two-thirds of the chlorine and of the dissolved nitrogen of the sewage. It is therefore too valuable to be wasted, and too impure to be discharged into a river, and can only be properly dealt with by irrigation.

General Scott's process has been carried on at Ealing, West Ham, and Birmingham. At Birmingham the sludge is dug into the ground.

(9.) *Whitthread's process*, which has also been favourably reported on by the British Association Committee, consists in adding to the sewage a mixture containing two equivalents of dicalcic phosphate, one of monocalcic phosphate, and a little milk of lime. The resulting precipitation was found to be very rapid, and the supernatant fluid clear and inoffensive. Suspended matters were completely removed, and the organic nitrogen nearly so. It was considered by the Committee that the manure would be valuable, as it contained a large amount of lime phosphate and 3 per cent of ammonia. As the effluent fluid contained phosphoric acid and ammonia it would be suitable for irrigation.

(10.) *Dr. Anderson's process,* first tried at Nuneaton, has been carried on much more successfully at Coventry. It consists in adding an impure sulphate of alumina, made by dissolving aluminous shale in sulphuric acid, to the sewer water, which is kept constantly stirred, and which afterwards flows into a series of settling tanks. The whole of the machinery is admirably planned, and the effluent, especially after it has passed through an adjoining filtering area, was at first very clear and fit to be discharged into any river; but latterly, owing to the increase of population, the works have here become inadequate for efficient purification and must be extended. Additional land too is required for filtration purposes.

Such are some of the more prominent chemical schemes which have been tried, but very few of them are now in operation. Indeed it may be said that no scheme of chemical purification can turn out a uniformly good effluent unless it is supplemented by land filtration or irrigation.

2. *Filtration processes.*

(1.) *Simple Filtration.*—In this process the sewage is merely strained or screened, so that, although almost all the suspended matters are removed, the effluent fluid is not by any means purified. The mud which collects at the bottom of the filtering tanks is generally mixed with the town ashes and sold as manure.

(2.) *Carbon,* as in Weare's process, has been tried to purify sewage by filtration, but it does not appear to have been very successful. Very possibly, if it could be obtained at a cheap rate and the filtration were made intermittent, it would be found to answer with small quantities of sewage where land cannot be procured.

(3.) *Upward Filtration.*—This process was at one

time carried on at Ealing, but the results were not satisfactory.

(4.) *Intermittent Downward Filtration.*—Amongst the numerous important experiments conducted under the direction of the Rivers Pollution Commissioners, there were none attended with better results than the filtration of sewage through a considerable depth of soil. The experiments were made on sand, on a mixture of sand and chalk, and on different soils. The results varied a good deal according to the quality of the soil, but in all of them it was found that the suspended matters were entirely removed, and that the organic carbon and nitrogen were greatly reduced. According to the report of the Commissioners, "These experiments also show that the process of purification is essentially one of oxidation, the organic matter being to a large extent converted into carbonic acid, water, and nitric acid; hence the necessity for the continual aëration of the filtering medium, which is secured by intermittent downward filtration, but entirely prevented by upward filtration."

The process was for some time carried on at Merthyr Tydfil, according to the plans of Mr. Bailey Denton, C.E.; and the following abstract from the report of the British Association Sewage Committee will afford a sufficient description of the various details and the results:—The filtering area or farm was about 20 acres in extent, and consists of a very porous gravelly subsoil, covered with vegetable mould. It was pipe-drained to the depth of about 7 feet, the drains conveying to the lowest corner, where the effluent water was discharged into a small stream leading into the river Taff. The area was laid out in square beds, intersected by paths, along which were constructed the main carriers, which received the sewage from the outfall sewer, where it was screened through a

bed of clay, and distributed it over the beds. In order to supply the sewage on the intermittent system, the area was divided into four equal portions, each portion receiving the whole of the sewage for six hours in succession, and thus leaving an interval of eighteen hours for rest and aëration of the soil. The surface of the land was cultivated to a depth of about 18 inches, and was laid up in ridges to allow of the sewage running down the furrows. The ridges were planted with cabbages and other vegetables.

The results of the process, as stated by the Committee, were highly satisfactory. All the suspended matters were removed, and the ammonia and nitrogenous organic matters were almost completely oxidised, so that they escaped in the effluent water as nitrites and nitrates. They added, however, that though the sewage was thus efficiently purified, the process could not be regarded as one of utilisation.

Since that report was published in 1872, additional land has been obtained to the extent of 230 acres, and the intermittent downward filtration process has been supplanted by simple irrigation, in order that better returns might be obtained.

The requisite extent of filtering area, as estimated by the Rivers Pollution Commissioners, is 1 acre drained to a depth of 6 feet for every 3300 of the population; but this ratio must vary according to the nature of the soil. The soil should be porous and the surface have an easy slope.

At Kendal, with a population of 13,700, this method has been successfully carried out on an area of 10 acres.

Stiff clay land can be converted into filtering beds by digging the clay to a depth of 5 or 6 feet, burning it, and mixing it freely with porous soil, the whole to be well drained; but the process, according to Professor Robinson, C.E., is costly, varying from £750 to £1000 per acre.

An acre of land treated in this way will efficiently purify the sewage of 1500 inhabitants.

3. *Irrigation.*—It is now generally conceded that this is the only process which fully meets all the requirements attaching to the disposal of sewage; in other words, it is the only one which, while it purifies the sewage efficiently, realises the highest profits, and may be carried on without creating any nuisance or detriment to the health of the neighbouring inhabitants. But in order that the process may be carried out satisfactorily, it is necessary—

(1.) That the acreage be sufficient. This will depend in great measure on the looseness or porosity of the soil; —hence to lay down as a rule that one acre should be allowed for every 100 inhabitants, which is the estimate usually given by engineers, is manifestly illogical.

(2.) The land to be irrigated must be drained, and stiff clayey soils broken up and mixed with ashes, sand, or lime.

(3.) The surface must be irrigated on the intermittent system, to ensure sufficient aëration of the soil.

(4.) The ground should be laid out in broad ridges and furrows, the sewage being conveyed along the tops of the ridges in open carriers, and made to flow gently down the slopes by inserting temporary sluices in regular succession and at regular intervals. At Breton's Farm, near Romford, the breadth of the ridge is 30 feet, giving a slope of 15 feet on either side of the carriers. At Lord Warwick's Farm near Leamington, Mr. Tough, the manager, informs me that the ridge varies from 50 feet wide, according to circumstances.

(5.) There must be a rotation of crops such as Italian rye-grass, peas, maize, different roots, cabbages, etc., and where land is plentiful, it always pays to let portions of it rest for a time for the growth of cereal crops.

(6.) The sewage should be delivered in a fresh state, and freed from the coarser portion of its suspended matters. This may be effected either by precipitation, filtration, or screening. At Lord Warwick's farm, the borough of Warwick farm, and the Rugby farm, the sewage is simply screened and delivered fresh on to the land.

Such, briefly, are the principal details connected with sewage-farming, and it is the neglect of one or more of them which has brought so much opprobrium on the system. If the irrigated soil becomes water-logged and swampy, the fault lies with the engineering and management, not with the system. Or, again, if the farm becomes a nuisance, it is because the sewage is not properly distributed, or the carriers kept free from deposit.

The comparative results of the different processes of purification are stated by the Rivers Pollution Commissioners as follows :—

Average Results.

	Percentage of Dissolved Organic Pollution removed.		Percentage of suspended Organic Impurity removed.
	Organic Carbon.	Organic Nitrogen.	
Chemical processes .	28·4	36·6	89·8
Upward filtration . .	26·3	43·7	100·
Downward filtration .	72·8	87·6	100·
Irrigation	68·6	81·7	97·7

This table shows that, in order to obtain the best purifying results, irrigation should always be combined with intermittent downward filtration. With regard to towns where a sufficiency of land cannot be procured for irrigating purposes, the process of downward filtration, as carried on at Kendal, should be adopted, and, in either case, the ashes and other town-refuse can be largely used

in clarifying or disinfecting the sewage before it is delivered on the filtering ground. Trade or manufacturing pollution must be treated according to the nature of the pollution.

Where no sufficient amount of land can be procured, as in the case of numbers of large inland towns, recourse must be had to purification by some chemical process; but in many instances the difficulties are so enormous that the pollution of neighbouring streams cannot be prevented unless at a cost which would irretrievably ruin commercial enterprise. Even were all trade-refuse and sewage excluded from streams, the mere surface-washings of large towns are sufficient of themselves to convert many of them into foul rivers, which no legal enforcement of riparian rights nor any number of Rivers Pollution Bills can ever render pure. Indeed, at Birmingham, Leeds, and other inland towns, the effluent is much purer than the filthy streams into which it discharges. Sanitary reformers are too apt to forget that, though streams and rivers may, and often do, prove valuable sources of water-supply, they are nevertheless the natural drainage outfalls of the country; and while many of them may be preserved from injurious pollution, there are numbers of others doomed to such an amount of pollution that, no matter what preventive means may be adopted, fish can scarcely live in them, and their turbid waters, however carefully purified, can never be safe to drink. It is evident, therefore, that with regard to river pollution, the special circumstances of every large town involved in sewage-difficulties must be taken into account, and that no hard-and-fast rule can be enforced by Act of Parliament which shall be applicable to all alike.

The following were the conclusions adopted by the Executive Committee of the Conference on the health and sewage of towns, held under the auspices of the Society of

Arts in May 1876, and they are appended here as affording a full and fair exposition of the various aspects of this difficult problem of sewage treatment and utilisation :—

"1. In certain localities, where land at a reasonable price can be procured, with favourable natural gradients, with soil of a suitable quality, and in sufficient quantity, a sewage farm, if suitably conducted, is apparently the best method of disposing of water-carried sewage. It is essential, however, to bear in mind that a profit should not be looked for by the locality establishing the sewage farm, and only a moderate one by the farmer.

"2. With regard to the various processes based upon subsidence, precipitation, or filtration, it is evident that by some of them a sufficiently purified effluent can be produced for discharge, without injurious result, into watercourses and rivers of sufficient magnitude for its considerable dilution ; and that for many towns, where land is not readily obtained at a moderate price, those particular processes afford the most suitable means of disposing of water-carried sewage. It appears, further, that the sludge, in a manurial point of view, is of low and uncertain commercial value ; that the cost of its conversion into a valuable manure will preclude the attainment of any adequate return in the outlay and working expenses connected therewith, and that means must therefore be used for getting rid of it without reference to possible profit.

"3. In towns where a water-carried system is employed, a rapid flow, thorough ventilation, a proper connection of the house drains and pipes with the sewers, and their arrangement and maintenance in an efficient condition, are absolutely essential as regards health ; hitherto sufficient precautions have rarely been taken for efficiently ensuring all the foregoing conditions.

"4. With regard to the various dry systems, where collection at short intervals is properly carried out, the result appears to be satisfactory, but no really profitable application of any one of them appears as yet to have been accomplished.

"5. The old midden or privy system in populous districts should be discontinued, and prohibited by law.

"6. Sufficient information was not brought forward at the Conference to enable the Committee to express an opinion in regard to any of the foreign systems.

"7. It was conclusively shown that no one system for disposing of sewage could be adopted for universal use ; that different locali-

ties require different methods to suit their special peculiarities; and also that, as a rule, no profit can be derived at present from sewage utilisation.

"8. For health's sake, without consideration of commercial profit, sewage and excreta must be got rid of at any cost."

To those who are interested in the monetary details of the question, the following table from the report on sewage-disposal by the Committee appointed by the Local Government Board in 1876, gives the cost in different towns by different processes in proportion to the annual rateable value, etc., for the year 1875:—

Name of Town.	Population (about)	Number of Houses.	No. of Water-Closets.	Annual Rateable Value.	Per £ of Rateable Value.	
					Sewage.	Scavenging.
BY IRRIGATION.						
1. Banbury . .	12,000	3,485	2,485	£34,104	1d.	—
2. Bedford . . .	18,000	3,500	3,000	65,000	1d.	—
3. Blackburn . .	90,000	16,700	730	235,127	8d.	3½d.
4. Cheltenham .	45,000	8,725	8,500	217,849	½d.	¼d.
5. Chorley . . .	20,000	4,000	200	54,407	4½d.	2½d.
6. Doncaster . .	20,000	4,300	—	68,721	3½d.	—
7. Harrogate . .	12,000	1,500	1,620	50,000	5¾d.	—
8. Leamington .	24,700	4,500	8,370	113,400	5½d.	1d.
9. Merthyr Tydfil	55,000	10,778	8,000	135,000	7½d.	—
10. Rugby . . .	8,400	1,700	1,400	45,000	1½d.	—
11. TunbridgeWells	23,000	5,750	5,635	142,914	10d.	—
12. Warwick . .	11,000	2,400	2,000	43,339	6½d.	—
13. Wolverhampton	71,000	14,000	750	210,000	2d.	1½d
14. West Derby .	31,400	—	3,220	163,000	4d.	1¼d.
BY LAND FILTRATION.						
15. Kendal . . .	13,700	2,727	450	£44,600	4d.	—
BY PRECIPITATION.						
16. Birmingham .	350,000	83,420	8,000	£1,229,844	4¼d.	5¾d.
17. Bolton-le-Moors	93,100	18,249	758	311,563	2d.	1½d.
18. Leeds. . . .	285,000	57,000	8,000	945,141	4¾d.	4½d.
19. Bradford . .	173,723	34,000	4,050	745,671	3¼d.	2¾d.
BY THE PAIL SYSTEM.						
20. Halifax . . .	68,000	11,218	2,600	£262,581	—	4d.
21. Rochdale . .	67,000	14,388	350	222,000	—	8¾d.

Section III.—Treatment of Village Slops.

Some slight reference has already been made to this part of the subject in the previous chapter, but the following remarks are submitted in the hope that they may prove of further service in assisting to clear up many of the difficulties in which this important question is involved. They are quoted from the pamphlet on Sanitary Defects in Rural Districts, already alluded to, and are an attempt to explain the principles on which my own recommendations have been based, when local circumstances are taken into account:—

"If the village drains into a large stream which is not used for drinking purposes below the village, and provided there is no nuisance at the outfall, I have not considered it necessary to recommend any interference. If, again, the village drains into an open ditch without creating nuisance, it will generally be found that a large catch-pit will suffice, provided all excremental filth and slaughter-house refuse are kept out of the drains. But in all cases in which there is nuisance at the outfall, or risk of water pollution used for drinking purposes, I recommend that the sewage, if it be at all possible, should be purified by irrigation or sub-irrigation, and failing these, that it should be filtered through a filter of sufficient size and on the intermittent downward filtration system. In some localities where the soil is porous, and the quantity of sewage comparatively small, a dumb-well in a field will satisfactorily solve the difficulty, or the outfall drain may be carried alongside a field ditch of lower depth, and the soil between will act as a ready filter. Indeed, in purely agricultural districts, the various expedients which might be easily adopted for the purification and utilisation of village slops are so accessible, so to speak, that in the great majority of instances there not

only need be no difficulty in treating them efficiently, but if properly utilised they will pay a fair return to any farmer who is public-spirited enough to take them. As a rule, however, the method of applying them to the soil is anything but satisfactory. Very often the quantity is so small that unless a tank is provided, which can be periodically emptied, the sewage trickles along the surface-gutter in the field, and finally disappears without contributing any of its fertilising properties, except it be to the sides of the gutter, on which some rank grass is found growing. But this insufficiency of volume, which constitutes the great objection which farmers have to village sewage, can easily be obviated by constructing one of Denton and Field's automatic sewage-meter tanks, in which the sewage can be collected for a period of twelve or twenty-four hours, according to the size of the tank, and by means of a self-acting syphon can be readily discharged when the tank becomes full. If land has to be purchased, half an acre to three quarters of an acre of ground properly drained and laid out would be quite sufficient to purify the slops and refuse-water of a village containing 800 to 1000 inhabitants, provided the sewage is applied on this intermittent system, and the subsoil is porous. Of course, if simple irrigation should be carried out, some three or four acres would be required, but in any case I should recommend the automatic sewage-meter tank to secure rapidity and intermittency of flow.

"Sometimes the question is raised as to whether village slops possess any agricultural value at all. For my own part, I am inclined to believe that they possess fertilising properties quite equal to those of ordinary town sewage; and, as an instance in point, I may mention that one of the rural sanitary authorities in my district receives a rental of about £6 an acre for a small field laid out in grass, which was purchased for the purification and utilisa-

tion of the slops of an average-sized village. Indeed, any one who takes the trouble to use the household slops in the garden will soon find for himself that the increase in garden produce will more than compensate for the extra trouble. And here I may remark, that part of the objections which farmers generally have to village sewage may be fairly attributed to their not unnatural opposition to any village improvements which are likely to increase the rates, and from which they do not receive any direct benefit. In places where both intermittent downward filtration and simple irrigation are objected to on account of their unsightliness, or the possibility of their giving rise to nuisance, the slops of a small village, if separated from the surface water, could be satisfactorily disposed of by sub-irrigation. In short, the difficulties to be encountered with regard to village drainage and purification of slops, as I have already said, are not so much engineering difficulties; the great difficulty in many rural districts is to get anything done at all in this direction.

"In sub-irrigation, the drains consist of common agricultural pipes laid at a depth of about 12 inches below the surface upon a bed of larger pipes divided longitudinally in half, so that the slops soak through between the open joints into the subsoil, part of them filtering into the ground, and part of them being absorbed by the vegetation on the surface. The system may be used in gardens, and is specially applicable to land which is reserved for pasture land. Mr. Field recommends that the drains should be taken up and relaid at least once a year, and it is always advisable to have the subsoil deep-drained. Where the system is adopted, as at Shenfield near Brentwood, for separate houses or groups of houses, care must be taken to avoid pollution of the wells by laying a longer or shorter portion of water-tight drain, according to circumstances, between the flush-tank and the sub-irrigation drains."

Section IV.—Sanitary Aspects of the Water-Carriage System of Excretal Removal and Disposal.

So much has already been said with regard to the evils resulting from collections of excretal matter in towns, that, at first sight, the superiority of any system which prevents these accumulations would appear to be placed beyond dispute. Unfortunately, however, the sewer-system is by no means free from serious dangers, and these have at times been attended with such disastrous consequences that many have been led to condemn it altogether. But an examination of a few of the more important outbreaks of disease, which have been attributed to the introduction of sewers, will show that such wholesale condemnation is groundless; that in fact such outbreaks are due to faults in the system, and not to the system itself. Thus, in the first inquiry of Dr. Buchanan, already alluded to (*Ninth Report of the Medical Officer to the Privy Council*), it was found that at Chelmsford the death-rate from enteric fever had increased since the introduction of the sewer-system 5 per cent, and at Worthing it had increased 23 per cent. In both these places, however, there was backing up of the sewage, and, as a consequence, the sewer-gases were forced up into the houses. At Chelmsford, the sewage was received into a tank or underground well; and, at times, when the pumping engine was not at work, the well filled, and choking of the out-fall sewer, and flooding of the cellars, ensued. At Worthing, again, although there was not so much backing up of the sewage, there was no provision made for ventilation; and hence, in the outbreak of 1865, the disease "almost exclusively attacked the well-to-do occupants of houses on the higher levels, where the water-closets were inside the houses, and almost entirely

spared the houses, mostly of a much poorer sort, situated on lower levels, where the closet was placed outside the house. It was not so in the times of cesspools; then these low-lying poor houses were far more attacked with fever than the others." At Morpeth it was also observed that occasional outbreaks of enteric fever had followed times of flood, during which the outfall sewer was under water.

Other instances of a similar character might easily be multiplied, but these are sufficient to show that all such outbreaks are due either to faulty construction, deficient ventilation, or imperfect flushing of sewers, or to backing up of sewage in low-lying towns. But while outbreaks of enteric fever do occasionally take place through the agency of sewers, and amongst others may be mentioned the outbreak at Croydon in 1875, there was no point more clearly established in the whole of Dr. Buchanan's inquiry than the remarkable reduction of the death-rate from this disease which had taken place in almost all the towns where a proper system of sewerage had been carried out. Thus, in nine of the twenty-five towns examined the diminution in the number of deaths was over 50 per cent, and in ten others from 33 to 50 per cent, the average reduction being about 45 per cent.

As regards other diseases, it appears that cholera epidemics had been "rendered practically harmless" in all of the twenty-five towns examined by Dr. Buchanan; and in the majority of cases the death-rate from diarrhœa had also been considerably reduced. Moreover, the general death-rate was lowered in some towns over 20 per cent; and the progress made by the inhabitants in cleanliness, decency, and self-respect, was found to be as striking as the improvement in their health measured by the mortuary returns. No doubt, the improved water-supply, which was generally obtained at the same time, aided in the common health-amelioration; but there can be little

question that the system of excretal removal by water-closets and sewers was the real agent at work. But unless sewers are well ventilated and kept regularly flushed, the best health results cannot be expected, and even then care must be taken that house drains are properly constructed, properly disconnected, and efficiently trapped and ventilated.

With regard to sewage-disposal it has already been shown in the previous chapter that irrigation is the only method which sufficiently purifies the sewage, and, at the same time, secures, in some instances at least, a profitable agricultural return. It now remains to be seen whether the carrying out of the system is attended with danger to public health. And here it may be premised that the same difficulty is encountered in sifting evidence as throughout the whole sewage-question,—the difficulty, namely, of dealing with sweeping generalisations which have been based on isolated or exceptional cases. For while, on the one hand, it appears that Dr. Letheby and others have condemned all sewage farms as pestilential swamps, Dr. Carpenter of Croydon and other strenuous advocates of the system, so far from pronouncing them as in any way dangerous to health, maintain that the general health of the neighbouring inhabitants is actually improved by them. But this is pushing the argument perhaps too far on both sides. No doubt some sewage farms answer to Dr. Letheby's description, especially such farms as have been laid out, without any due regard to drainage, in low-lying districts, and those that have been planned on the "catch-water" system. It is evident that this latter system necessitates a swampy condition of both soil and subsoil, unless the ground is porous and well drained, inasmuch as the sewage passes over successive areas of land, overflowing from each into a "catch-water" ditch, which conveys it to the next. Again, when the sewage

is not delivered in a fresh state, and at least properly strained, if not disinfected by some precipitation process, offensive emanations are undoubtedly given off, especially when the carriers are not kept clean. But though all this is perfectly true, it is no argument against the system when properly carried out, unless direct evidence can be brought forward to show that, even when the engineering and management are alike satisfactory, there is not only possible but actual risk to health. Such evidence, however, does not appear to be forthcoming; and even with regard to farms which have neither been planned nor are conducted according to the most approved principles, the evidence as regards the production of disease is of a negative character. Thus, Sir Robert Christison testified concerning the Craigentinny Meadows, near Edinburgh—"I am satisfied neither typhus, nor enteric fever, nor dysentery, nor cholera, is to be encountered in or around them. whether in epidemic or non-epidemic seasons, more than in any other agricultural district of the neighbourhood"—(*First Report of the Rivers Pollution Commissioners*). At Norwood, again, where the farm lies on a deep clay soil, Dr. Cresswell stated that the health of the neighbouring inhabitants was in no way influenced by it; and according to the Ninth Report of the Medical Officer of the Privy Council, the irrigation Works at Worthing did not cause any description of nuisance or injury to health. In my own district, containing at least ten sewage farms, and some of them of considerable size, no cases of illness which could be traced to this source have ever come under my notice. So far, therefore, the production of disease arising from fæcal pollution of air or water by the system, when properly managed, is not substantiated. But it was feared at one time that entozootic diseases would be greatly propagated, no matter how efficiently the system might be carried out, and Dr. Cobbold's high authority gave currency

to the belief. Dr. Cobbold, however, with rare scientific candour, and after careful investigation, has since stated that the fears which he originally entertained have not been realised. Animals fed on sewage produce have not been found to be parasitically diseased, nor has any case of parasitism been detected in man which could be traced to the effects of sewage irrigation.

Alarmists, too, have not been wanting, who strenuously maintain that the milk of cows fed on sewaged grass is poor in quality, rapidly decomposes, and is unfit to be used. But so far is this from being the case, that there is an overwhelming amount of evidence to the contrary; and, amongst other instances, I may mention the following:—Dr. Brushfield, formerly of Brookwood Asylum, states that he has tried the experiment, and found that cows fed on sewaged grass yield more and richer milk than cows fed on ordinary pasture, and this is also the experience of Mr. Tough, the manager of Lord Warwick's farm. Further, Dr. Hill of Birmingham and Dr. Swete of Worcester, have frequently analysed both milk and butter, and with the most satisfactory results. It need hardly be said that on a well-conducted sewage farm, no sewage is applied for several days before the grass is mown, so that it is always perfectly clean.

CHAPTER XIII.

SOILS AND LOCALITIES—THEIR INFLUENCE ON PUBLIC HEALTH

WHAT is called the Geographical Distribution of Disease, except where studied in respect to vast tracts of country and different climates, depends upon so many complex conditions, that it becomes very difficult to determine what may be the precise influence on health exerted by the purely physical features of soil or locality. We know, for example, that the class of diseases which characterise the tropical zone are the worst kind of malarial fevers, associated more especially with dysentery, diarrhœa, cholera, specific yellow fever, and hepatic affections, and that these fevers prevail with the greatest intensity in flat low-lying tracts of country in the vicinity of marshes, the borders of lakes, the shores of the sea, and the banks of rivers. Indeed the geographical data collected by medical writers from the days of Hippocrates downwards go to prove that every country is unhealthy in proportion to the extent of undrained alluvial or marshy soil which it contains, and that the excess of disease engendered is mostly of the remittent and intermittent febrile type. In the time of Sydenham, London was infested with epidemic intermittent fever and dysentery; but for years back, owing to the construction of sewers and a general system of deep drainage, cases of ague contracted in London are hardly known. Other towns both in this country and

France, such as Portsmouth, Bordeaux, and Rochefort, which were once the seat of malarial diseases, have in like manner been rendered comparatively healthy. Even in the fen districts of Suffolk and Norfolk ague, which was once so common, is now dying out, owing to the drainage improvements which have been instituted. What the exact nature of this malarial poison is has not yet been satisfactorily determined. According to Crudeli, Klebs, and others it is due to an organism which they have named the *Bacillus malariæ*, but this view requires further confirmation before it can be accepted. There can be little doubt, however, that the noxious agent, whatever be its exact nature, is a product of vegetable development and propagation associated with heat and moisture.

But when we come to study the distribution of disease in a country so limited in extent as Great Britain, and with climatic conditions so fairly uniform throughout, the process of eliminating other than purely local causes becomes exceedingly difficult. For example, we know that phthisis is much more prevalent in certain localities than in others; but in many of these districts it is found that heredity, consanguineous marriages, poor feeding, overcrowding, or industrial occupations, play a far more important part in the production of the disease than topographical conditions. Indeed it may be said generally that the purely artificial conditions in and around dwellings are of far greater moment from a public health point of view, in this country at all events, than geological formation or nature of subsoil. Nevertheless, geological conditions, in so far as they influence surface conformation, and the movement of water and air in the soil of different localities, are very important factors in the maintenance or impairment of health, and merit special attention in sanitary investigations.

Section I.—Topographical Conditions.

These refer to the configuration and elevation of the surface, the exposure to certain prevailing winds or otherwise, and the relations to watersheds or river-systems. The expressions high and exposed, flat and low-lying, sheltered, sloping, undulating, and the like, have a certain though varying significance, in differentiating the various factors affecting the salubrity of any given locality. In hilly districts, the most unhealthy localities are enclosed valleys and ravines where the air cannot circulate freely and must stagnate, while as regards a comparatively flat district, the insalubrious spots are depressions below the level in which the subsoil water crops up to the surface. Vegetation has also an important bearing on the health of a locality. Herbage on sound soils is always healthy, but isolated country houses and small villages embowered among trees and low-lying, become unhealthy when the trees are so plentiful that they interfere with the free movement of air, and this unhealthiness is increased when the autumn leaves are falling. The banks of sluggish rivers which are flooded in times of heavy rainfall are always more or less unhealthy, and so too is the neighbourhood of flat estuaries where the mists creep up in the evening and hang in the early morning.

Section II.—Geological Conditions.

These refer to the nature of the soil and the geological formation. Reference has already been made in the chapter on Dwellings to the dangers attaching to made-up soils consisting of ashes, and house or factory refuse of all kinds. It is true that such soils purify themselves after a time by oxidation, but as a condition of purification the

subsoil water must have a free outlet. No building should be permitted on sites of this description without making trial-holes and ascertaining whether all the organic matters have become decomposed; and even then the surface should be asphalted or concreted over, and free ventilation under the floors secured. Sandy and gravelly soils are always healthy except when they lie much below the general surface, and thus become water-logged. Clay and dense marls, on the other hand, are not so healthy unless the surface is undulating and there is a good fall in streams and brooks for the removal of the surface and subsoil water. Low-lying clayey soils are cold and damp, and favour the development of phthisis, rheumatism, and catarrhs.

As regards geological strata, it may be said generally that the granitic, metamorphic, and trap rocks are usually healthy. The surface conformation is hilly or undulating, the air is comparatively dry, and the rainfall rapidly runs off. So, too, with the clay slate formation; but water is often very scarce. In districts where the limestone and magnesian limestone formations prevail, the surface is generally undulating and healthy, but water is always hard, and often difficult to find. Of the different kinds of limestone, oolite is considered to be healthier than magnesian limestone; indeed goitre and calculus are more common in districts where this latter formation abounds than elsewhere. The chalk formation, when permeable, is very healthy, but where it overlies beds of clay it often becomes marshy and malarious, as in large tracts of America. The permeable sandstones and hard millstone grits are also healthy, and so, too, are gravels from which the subsoil water can drain freely away. But the principal factors which influence the salubrity of the subsoil of a locality are its power to absorb and retain heat, the character and movements of the ground air, and the nature, movements, and level of the subsoil water.

1. As regards power of absorbing and retaining *heat*, no extended series of observations, except those of Schübler, have yet been made; but according to him sand heads the list, then, (in order), light clay, gypsum, heavy clay, clayey earth, pure clay, fine chalk, and, lastly, humus. No doubt the temperature of the soil exerts a very considerable influence on the oxidation of any organic matter which it contains, and therefore assists in determining the character of the ground air.

2. *Ground Air.*—The nature of the ground air has been examined by many observers, and notably by Pettenkofer, Fleck, Fodor, and Nicholls of America. Its composition and amount are very variable, but its chief ingredient is carbonic acid gas, due no doubt to the oxidation of the organic matter contained in the soil. Occasionally it contains carburetted hydrogen, and in soils more or less damp, and where the water is hard, owing to an excess of sulphates, a small amount of hydrogen sulphide is usually found. According to Boussingault's experiments the amount of carbonic acid varies from 2·4 per 1000 volumes to 9·74 in soils which have recently been manured, while Pettenkofer and Fleck have found it to rise as high as 80 per 1000 volumes in gravelly soils at depths of from 5 to 13 feet. Indeed, Pettenkofer has proposed that the amount of carbonic acid gas should be taken as the index of the other impurities, but this is manifestly open to objection because the more porous the soil, the greater the amount of atmospheric air present. In order to estimate the porosity of soils, or the total amount of ground-air, the following is the plan adopted by Pettenkofer. A sample of the loose soil is rubbed down to a powder but without crushing it, and dried at a temperature of 100° Cent. (212° Fahr.) A portion of it is introduced into a burette, which is gently tapped to force the air out of the interstices as far as possible. This

burette is connected with another by means of an india-rubber tube provided with a clamp, and this latter is filled with distilled water. The two are then fixed side by side on the same level, the pressure of the clamp is removed, when the water in the second burette flows into the first, gradually rises through the soil, until it appears as a thin film covering the top. The quantity of water which has thus passed from the second burette is then read off, and will represent the amount of air contained in the sample of soil, while the percentage of air in the soil will be obtained by the following formula: $\frac{a \times 100}{b}$, where a represents the amount of water used and b the quantity of dry soil.

It need hardly be said that not only does the quality of the air vary in different soils according to their nature, but it is constantly varying owing to its continual movement, and especially where soils are dry and porous. These movements are largely influenced by temperature, barometric pressure, force and direction of winds, rainfall, and level of subsoil water. But there is another condition which, though artificial, exercises even a more important influence, so far as health is concerned, than perhaps any of these. For example, during cold weather a house which is well warmed, and has underground cellars or kitchens with no ventilated or impervious covering over the subsoil, is continually drawing air from the soil, and often from considerable distances. Thus the foul air from a cesspool, according to Dr. Fyffe, was sucked into a house a distance of twenty-seven feet, and coal-gas from leaky pipes has been found to travel long distances. According to Dr. Parkes, the diseases which are more especially attributed to telluric effluvia are paroxysmal fevers, cholera, enteric fever, yellow fever, bilious remittent fever, and dysentery.

3. *Water in Soils.*—The water in soils is generally

considered under two aspects, viz. the amount of water mixed with air to be found in any given soil, known as *moisture*, and that subterraneous lake or sheet of water which exists in all soils at varying depths, and known as *ground water*. The amount of moisture will depend on the nature of the subsoil, the amount of rainfall, the configuration of the ground, and the quantity of water derivable from the ground water itself. Some soils take up large quantities of water. A loose sand, for example, may retain as much as 2 gallons per cubic foot, and ordinary sandstone may hold 1 gallon. Clay takes up 20 per cent, chalk 13 to 17 per cent, and humus 40 to 60 per cent.

The ground water is in constant movement, and generally in the direction of the sea, or the nearest watercourse. The level from the surface of the ground varies from 2 or 3 feet to several hundreds, and depends upon the porosity or compactness of the soil, the amount of rainfall, the configuration of the ground, and the dip and distance of impermeable strata. The variation in the level of the ground water which can easily be measured in wells, is considered by Pettenkofer, Fodor of Buda Pesth, and others, to be a most important factor in the etiology of diseases, such as cholera and enteric fever.

Section III.—The Relations between Soils and Localities and Disease.

As a general rule, it may be said that a persistently low ground-water level, say 15 to 20 feet, is healthy; that a persistently high level, say 5 to 3 feet, is unhealthy; and that a level which fluctuates suddenly and considerably is more unhealthy still.

1. *Enteric Fever and Cholera.*—According to Pettenkofer, enteric fever is much more likely to become pre-

valent when the ground-water level is at its lowest, and no doubt this view has been corroborated to a very large extent by observations which have been made not only in Munich, but in other parts of Germany, such as Berlin and Leipzig. This theory is based upon the assumption that in addition to impurity of soil from animal impregnation, which is acted on by temperature, moisture, and air, there must also be the entrance of a specific germ; and he also applies his theory to the causation of cholera. But in this country Pettenkofer's views have not been confirmed, and though outbreaks of enteric fever have been found to be associated with rapid rising or falling of the subsoil water, they have been originated by the polluted water in the wells, into which the ground impurities have been washed, and not by the ground air. It is quite probable too that there are other causes in operation which must materially effect the validity of any theory of the kind. For example, it is well known that the level of the ground water is lowest in the warm and dry seasons of the late summer and autumn, and these are the seasons when sewer and drain emanations become most prevalent and offensive. Then, too, there is hardly any fact which is more gratifying so far as sanitation is concerned than the steady decline of the prevalence of enteric fever in towns provided with a wholesome water supply, and with a drainage system properly constructed and ventilated, and kept regularly flushed. Indeed in many towns cases of enteric fever are now of the rarest occurrence, so much so that the disease may be said to be banished altogether; and yet in these towns there must be rising and falling of the ground water, though of course deep drainage must permanently lower its level. So far as the ground water is concerned, the fever-rate has diminished, because wells are no longer used. And here it may be pointed out that there are carefully investigated

instances recorded, such as the oft quoted outbreak of enteric fever at Zurich, which are altogether subversive of Pettenkofer's theory, the disease rising and falling with the level of the ground water. But even in cases such as this, it is highly probable that the real cause is the pollution of the well water; surface impurities and impurities in the subsoil being washed into the wells as the level of the ground water rises. Pettenkofer further maintains that the virulence of the specific contagia of enteric fever and cholera is specially intensified by warmth and dampness of subsoil, and this latter factor operates all the more powerfully when the ground water subsides rapidly after a sudden rise.

2. *Diarrhœa and Dysentery.*—There can be no doubt that both these diseases are largely influenced by conditions of subsoil. It has been pointed out in a previous chapter, for example, that polluted well-water, alike in towns and country districts, is a fertile source of diarrhœa; while temperature of the subsoil, as in Leicester, where numbers of houses have been built on made up ground, is an index of the dangers attaching to a filth-sodden subsoil. As the temperature rises, the sick and death-rate from infantile diarrhœa increases. In warm climates, the prevalence of dysentery is largely due to subsoil conditions.

3. *Malaria.*—It has frequently been matter for debate whether malarial fever is due to inhaling the air of marshes or drinking the water; but there is now a vast amount of evidence which proves conclusively that the air alone is frequently the medium through which the disease is conveyed, and, as already pointed out, the morbific agent is believed by many to be a specific germ known as the *Bacillus malariæ.* But whatever be the nature of this agent, the factors which are essential to its development are heat of soil, moisture, air, and a certain amount of

impurity which in all probability is of vegetable origin. In so-called malarious countries, outbreaks of the disease may be connected either with the rise or fall of the ground-water level. Obstructions to outflow of the ground water, as, for instance, during the construction of the Ganges and Jumna canals, have often been followed by wide-spread malarial epidemics; while epidemics quite as severe have been known to follow heavy rainfalls, succeeded by a rapid rise in the ground-water level, as at Kurrachee in Scinde, in 1869. Further, it has been noted that disturbances of the subsoil during the excavation of canals, the construction of dykes, and the reclamation of marshy land, by exposing the earth impregnated with organic matter to the energetic action of the sun, has often been known to be followed by increased prevalence of malarious disease. On the other hand deep drainage, as has already been pointed out, removes the danger.

4. *Phthisis.*—Amongst the numerous valuable reports which Dr. Buchanan, in his capacity of Health Inspector, has submitted to the Privy Council, there is perhaps none which excited greater interest at the time than his report "On the Distribution of Phthisis as affected by Dampness of Soil." In a previous investigation regarding the effects of improvements in drainage and water-supply, Dr. Buchanan had ascertained that in certain towns which had been improved in this respect, the mortality from phthisis had greatly diminished; and not only so, but the rate of diminution was found to correspond with the extent of the drying of the subsoil. This result, which was so far unexpected, led to the important inquiry above mentioned, and the principal facts connected with both may be briefly summarised as follows:—

In the first inquiry, it was found that wherever the drying of the subsoil had been effected, either by the construction of drain-sewers, or by special drains and deep

storm-culverts, when the pipe-system was carried out, the mortality from phthisis had decreased from about 50 per cent downwards. In Salisbury, for example, the death-rates from phthisis had fallen 49 per cent; in Ely, 47; in Rugby, 43; in Banbury, 41; and in thirteen other towns the rate of diminution, though not so marked, was nevertheless noteworthy. On the other hand, it also became apparent that in certain towns, such as Alnwick, Stafford, Morpeth, and Ashley, where no drying of the subsoil had been effected, there was no reduction in the phthisis death-rate, even although the greatest possible progress had been achieved in the removal of filth. This was owing to the fact that in these towns impervious pipe-sewers had been laid down, without making any provision for deep subsoil-draining, the storm water being carried off in superficial culverts. In some towns, again, such as Penzance, where the subsoil was already dry, the phthisis death-rate remained stationary; and in others, where plans of drainage had been carried out, the sanitary advantages, as regards phthisis, were nullified, because, as in the case of Carlisle, they were so low-lying that the subsoil was at all times more or less water-logged. So far, therefore, the relation between dampness of soil and phthisis, as one of cause and effect, became highly probable, and Dr. Buchanan's second inquiry converted the probability into a scientific certainty.

In this special inquiry (see *Tenth Report of the Medical Officer of the Privy Council*) the various registration districts in the three south-eastern counties of England, beyond the limits of the metropolis, were brought under detailed examination, and considered in two ways. Firstly, the true phthisis-rate of the population was ascertained, and due allowance made for the causes of the disease which were likely to influence the rate besides the nature of the soil; and secondly, the numbers of the population, in each district, that were found "living upon various

kinds of soil, and under various topographical conditions," were also noted. The results of these two separate lines of investigation were then brought together, and statistically compared.

Without entering into any of the geological details, which are fully given in Dr. Buchanan's report, it may be said, generally, that the dampness or dryness of a soil depends partly on whether, if pervious, it is retentive of water, or, if impervious, the water can readily drain away. Again, it is obvious that pervious soils may present very different degrees of dryness or wetness, according to the elevation of the ground, and the dip of underlying impervious beds. Thus, a stratum of gravel or chalk, covering a sloping bed of impervious clay, is necessarily a dry soil, because the rainfall readily sinks to and flows along the surface of the impervious slope, whereas the same stratum in a valley may be actually waterlogged, although the depth of the stratum may be the same throughout. Bearing in mind, then, the topographical relations as well as the physical qualities of different soils, the following general conclusions, given by Dr. Buchanan as the result of his inquiry, will be at once understood :—

"(1.) Within the counties of Surrey, Kent, and Sussex there is, broadly speaking, less phthisis among populations living on pervious soils than among populations living on impervious soils.

"(2.) Within the same counties there is less phthisis among populations living on high-lying pervious soils than among populations living on low-lying pervious soils.

"(3.) Within the same counties there is less phthisis among populations living on sloping impervious soils than among populations living on flat impervious soils.

"(4.) The connection between soil and phthisis has been established in this inquiry—

"(*a*) By the existence of general agreement in phthisis-

mortality between districts that have common geological and topographical features, of a nature to affect the water-holding quality of the soil;

"(*b*) By the existence of general disagreement between districts that are differently circumstanced in regard of such features; and

"(*c*) By the discovery of pretty regular concomitancy in the fluctuation of the two conditions, from much phthisis with much wetness of soil to little phthisis with little wetness of soil.

"(5) The whole of the foregoing conclusions combine into one—which may now be affirmed generally, and not only of particular districts—that wetness of soil is a cause of phthisis to the population living upon it."

It is interesting to note that this new discovery in the etiology of disease, which in this country has been associated with Dr. Buchanan's name, had already been brought to the notice of the profession in America by Dr. Bowditch, of Boston, U.S. It would appear, however, that Dr. Bowditch's researches were not known in England until after Dr. Buchanan's inquiry had been finished; and although the priority rests with him, the credit of independently establishing causation of phthisis by dampness of soil as a general law in this country remains with Dr. Buchanan. But it would be unfair not to quote Dr. Bowditch's own remarks. In a very able and lucid address delivered to the Massachusetts Medical Society in 1862, he submitted the two following propositions as containing the essential results of very extended inquiry:—

"First.—A residence in or near a damp soil, whether that dampness be inherent in the soil itself, or caused by percolation from adjacent ponds, rivers, meadows, marshes, or springy soils, is one of the principal causes of consumption in Massachusetts, probably in New England, and possibly in other portions of the globe.

"Second.—Consumption can be checked in its career, and possibly, nay probably, prevented in some instances, by attention to this law."

But in addition to phthisis there are several diseases, such as, rheumatism, heart-disease, and catarrhal complaints, which are intimately connected with dampness of subsoil, and it probably influences to a large extent the prevalence of other diseases. Thus, Dr. Blaxall, one of the Local Government Board Inspectors, in a recent report on the prevalence of measles, whooping-cough, and pneumonia, in Swindon, shows that these diseases were far more fatal in New Swindon than in Old Swindon; and he attributes the increased severity in the former place to the dampness of subsoil upon which the new houses are built, and the complete absence of precaution to prevent the ground air rising into the houses. New Swindon is built on kimmeridge clay, and was formerly much liable to floods. Old Swindon, on the other hand, stands 100 feet higher, and is built on limestone and sand. Indeed, the presumption would appear to be that in localities where climatic and topographical conditions are closely similar, dampness of subsoil would declare itself as an important agent in the development or spread of all diseases, which directly or indirectly affect the respiratory organs. Diphtheria, croup (not spasmodic), and pneumonia, are all of them diseases which have often been found to be associated with conditions of soil, such as dampness, or filth impregnation polluting the well water and ground air, and no doubt other diseases of the zymotic class, as for example erysipelas and pyæmia, are largely influenced by these important factors.

Concluding Remarks.—Although many valuable contributions have been made to the geographical distribution of disease in different regions of the globe, very little of a concise and well-defined nature has been achieved so

far as regards this country. Indeed, Mr. Haviland may be said to be the only writer who has investigated this subject with any approach to completeness, and even his results are open to the objection that the statistics on which he based his inductions often applied to districts which were much wider than the town or village dealt with. Thus it generally happens that a small town only forms part of what is called a registration sub-district, and in this wider district the topographical and geological conditions may vary greatly in different parts. But many of Mr. Haviland's generalisations are based on statistics which apply to large tracts of country, and so far they claim for themselves a certain value, but, even then, they are intimately associated with conditions which are purely climatic. The diseases which are especially investigated in his painstaking work on the *Geographical Distribution of Diseases in England and Wales* are heart-disease, cancer, and phthisis, and, briefly summarised, his main conclusions are these :—As regards heart disease and dropsy, statistics showed that the highest mortality districts are always to be found in the most sheltered spots, and are generally those which lie nearest on the leeward side to the sheltering range. He attaches great importance to the purifying influence of sea-winds, and further states that agricultural labourers, owing to poor living, low wages, and having to turn out in the early morning when the dew is on the ground, the air chill, and the exhalations of the night are most noxious, are especially liable to rheumatism and all its complications. No doubt their liability to rheumatic disease is greatly increased by exposure to wet, and having to live in cottages which often have damp floors and are built on undrained ground.

With regard to cancer, he found that in counties having a high mortality from this disease, the tributaries of rivers flow from soft, marly, and easily disintegrated

rocks into sheltered valleys through which the main rivers flow. During times of heavy rainfall these rivers invariably flood their adjacent districts, and have generally their waters coloured by suspension of alluvial matter. In all these respects the Thames valley is cited as a typical cancer field. Statistics also go to prove that cancer does not thrive on a high dry soil.

With respect to phthisis his conclusions generally bear out those already stated in connection with dampness of soil, namely, that damp clayey soil, whether belonging to the wealden, oolitic, or cretaceous formations, is coincident with a high mortality from this disease. Basing his conclusions on the statistics of wider areas, he further states that coincident with sheltered positions there is a low rate of mortality, and that the easterly ridges of the south-east coast of England are characterised by a high mortality, owing mainly to their general aspect being favourable to the malign influence of the east wind. This also applies to the eastern counties having a high mortality, while, the lower lands are characterised by clays of the Eocene period, especially the London clay. He further found that high elevated regions of non-ferruginous carboniferous limestone, coal, and silurian formations, form the sites of the most extensive series of high mortality districts, and especially instances Anglesey. On the other hand he states as a general rule that a warm, fertile, and ferruginous soil is coincident with a low mortality from phthisis.

The main conclusions therefore to be drawn from all these inquiries into the relations between soil and disease are these, that, so far as possible, dryness should be secured by drainage, and that ground air should be excluded from houses by asphalting or cementing over the surface, and providing for free ventilation under ground floors.

CHAPTER XIV.

INFECTIOUS DISEASES—THEIR MODE OF PROPAGATION AND PREVENTION

By infectious diseases is meant all diseases which are communicable from one person to another, whether by actual contact or through the agency of certain media, such as air or water. Many of these, however, are comparatively of such little hygienic concern, that they may be excluded from further notice; as, for example, certain parasitic diseases of the skin, and others, which are never found to affect communities in an epidemic form. The preventive measures, therefore, or other protective means, which will be here considered apply mainly to the class of diseases termed zymotic, such as smallpox, cholera, typhus fever, enteric fever, scarlet fever, relapsing fever, measles, and the like. Although, in preceding chapters, the mode of propagation of several of these diseases has been considered more or less fully in detail, it will nevertheless be of advantage to allude very briefly to some of the opinions which are entertained concerning their etiology. According to the germ theory of infectious diseases, the origin, *de novo*, of a fever poison is as impossible as the spontaneous generation of plants or animals; the inference being that enteric fever, for example, can only be developed from the specific contagium of the fever, just as a case of smallpox cannot occur without infection from some pre-existing case. Now, to this it

may be replied that the poisons of all the acute specific diseases must have originated at one time or another independently of pre-existing cases, and there is no reason to believe, therefore, that the causes which led to the development of the first cases should not be in operation at the present day.

As regards the various views which are at present entertained with respect to the nature of contagia little need be said, because so much is still left open to controversy. Some maintain that the particles are of animal origin, born in, and only growing in, the body; in other words, that they are minute portions of bioplasm endowed with a certain amount of independent life, which enables them to thrive on suitable pabulum. This view has been ably advocated by Dr. Beale, and has been modified by Dr. Richardson under the name of the glandular origin of disease. Others, such as Hallier, maintain that the particles are of fungoid nature, and simply grow in the body after having been introduced from without; while some of the most careful observers hold that they are of the nature of the *Schizomycetes*, such as *Bacteria, Microzymes, Bacilli, Vibrios, Monads*, etc. No doubt these minute organisms are intimately associated with some of the so-called specific diseases, and the researches of Pasteur on fowl-cholera and charbon go to prove that these two diseases are not only due to *Bacteria*, but that they can in all probability be prevented or modified by cultivated virus. The inquiries into the wool-sorters' disease at Bradford afford further evidence that it is identical with the anthrax of cattle, in which the *Bacillus anthracis* plays such a prominent part, while *Bacilli* were found to be the diagnostic agents in the poisoning by hams at Welbeck (see Chapter II.) Then, too, the researches of Koch into the nature of phthisis and cholera, and the association of both diseases with different, and, as he

maintains, specific *Bacilli*, open up wide fields for further investigation. It is true that as regards the specific connection of *Bacilli* with cholera his views have not been confirmed by Klein—indeed have been strongly disputed; nor has his theory respecting the part which *Bacilli* play in the causation of disease been generally accepted. Indeed the very universality of these various micro-organisms affords the strongest argument against the view that they constitute the contagia of any of the specific diseases, and there are good grounds for believing that further pathological research will demonstrate their presence in the blood of patients who have died from other diseases.

The fact is, the question at issue has been discussed on too narrow a basis, and the possibility of the several zymotic diseases differing greatly has been too much lost sight of. Just because all of them are infectious, it has been argued that none of them can be generated except by a specific contagium. But even as regards this infectious quality, there is the widest possible divergence between them; for while, on the one hand, we find that smallpox and scarlet fever are extremely infectious, we find, on the other, that enteric fever and erysipelas have only a limited power of propagating themselves, except under insanitary conditions which are favourable to their development and spread. Moreover, while, in regard to smallpox, it can never at the present day be traced to any other cause than infection, in diphtheria it is comparatively rare that isolated cases can be traced back to any pre-existing case; and the same remark applies generally to sporadic cases or limited outbreaks of enteric fever as they occur in rural and small urban districts. Then, again, it is a matter of almost daily observation that pyæmia and puerperal fever are not only generated *de novo*, but the researches, more especially of Dr. Sanderson,

show that they can be generated at will, and when so generated they become, under certain circumstances, eminently infectious. It is no argument, therefore, that because a disease is infectious it cannot be generated *de novo*, and the argument becomes weaker still when it is remembered that several of these diseases do not breed true, nor do they run a definite course. Thus we find erysipelas and pyæmia running into each other, and that either of these, or scarlet fever in its varied forms, may generate puerperal fever in the parturient woman. Although the part which filth plays in intensifying the virulence of specific diseases is readily admitted by all, there are many who begin to recognise that some diseases which, in the sense of their being able to continue their species from man to man, are quite as specific as small-pox or scarlatina, have undoubtedly a birth-place exterior to man,—a birth-place among the common putrefactive changes of dead organic matter. All these, however, are questions which still afford ample room for speculation and research. Meanwhile it is encouraging to sanitary efforts to find that as civilisation advances, epidemics decrease in frequency and intensity, and that nothing tends so much to weaken their power and circumscribe their range of action as a free circulation of pure air in inhabited places, a good supply of pure water, and a sufficiency of wholesome food.

In preceding chapters the mode of propagation of several of these diseases has been considered more or less fully in detail. It has been shown, for example, that there is good reason to believe that the contagia of cholera and enteric fever are contained in the alvine discharges, which, in their turn, pollute the water-supply or the respired air; that typhus fever is essentially a disease of overcrowding; and that relapsing fever is associated with wide-spread insufficiency of food. It has also been shown

that, when the local circumstances which are found to favour the propagation of any one or other of these diseases in an epidemic form are improved, the extension of the disease is checked, and its ultimate extinction from a portion of the community secured. Improvement of local circumstances is, therefore, a most important, and perhaps the most important, part of prevention. But there are other measures which are found to be of immense service in checking the course of any epidemic,—such as the isolation of the sick, the use of disinfectants, and the destruction of the contagia by any other means which may be deemed most efficacious. In order, however, to be able to apply these measures judiciously, some knowledge of the distinctive features of the several infectious diseases, as well as their mode of propagation, is essential, and it will be convenient to treat these diseases in the order in which they are given in the returns of the Local Government Board.

1. *Smallpox.*—At what period smallpox was first introduced into this country history does not enlighten us, but according to authentic records it certainly existed both here and on the Continent prior to the ninth century, and there are notices of severe epidemics from the twelfth century onwards. Indeed, after the disappearance of the plague, it became the severest scourge of the country, and so late as the close of the last century the deaths from this disease alone exceeded 10 per cent of the total number of deaths. As stated in the introductory chapter, the practice of inoculation introduced into this country on the representations of Lady Mary Wortley Montagu about the year 1720, while it modified the severity of the attack, assisted rather than otherwise the spread of the disease itself, and it was not till some time after Jenner's grand discovery of vaccination in 1796 had become general throughout the country that the gradual

decline in the rate of mortality began to make itself apparent. Previous to the introduction of vaccination, it spared neither age, sex, nor position in life; every fifth person attacked died, and many of those who survived were hideously disfigured or maimed for the rest of their days. There is probably no disease so infectious, and none in which the infective material can operate at so great a distance. From cases which have come under my own observation, I have reason to believe that the contagium may be wafted from house to house on opposite sides of a narrow street, and, as the inquiries into the spread of the disease in the neighbourhood of Fulham and Hampstead hospitals have shown, there are grounds for assuming that the contagium may be carried through the air and operate at considerable distances under certain atmospheric conditions. It is true that Mr. Power's views as regards aereal extension have not received general acceptance, and, indeed, have been keenly disputed, but at the same time they point to the advisability of locating smallpox hospitals in situations as isolated as possible; and as regards infectious hospitals, they prove the expediency of entirely separating the smallpox block from the blocks used for the reception of cases of other kinds of zymotic disease.

The period of incubation varies from twelve to fourteen days, and the fever is ushered in with shivering, headache, pain in the loins, and often vomiting. These symptoms vary according to the severity of the attack, but the central pain in the lumbar region and vomiting are especially characteristic of the disease. The shivering is followed by fever more or less acute, and in severe cases delirium may set in within twenty-four hours. On the third day a papular eruption appears on the forehead, neck, and hands, and afterwards on the trunk and legs. If these papules remain separate and distinct, the disease

is designated variola discreta or simple smallpox; but if they are so numerous as to coalesce, the case is known as one of confluent smallpox, or variola confluens. In hæmorrhagic, black, or malignant smallpox, the patient may succumb before there is any distinct eruption beyond a bright red stippling of the skin, most abundant on the lower part of the abdomen and thighs, which deepens into a dusky violet hue, accompanied often with flea-bite petechiæ, and hæmorrhage from the mucous surfaces.

In the discrete form of the disease the papules become vesicles on the third day, surrounded by an inflamed area. On the fifth day the vesicles become pustular, and the pustules subsequently become depressed in the centre or umbilicated; while on the ninth or tenth day they break and form scabs which, as they shrivel and dry up, begin to fall off about the fourteenth day of the fever.

In variola confluens, the initial symptoms are more intense; the vesicles run into each other, and the face becomes very much swollen. After they become pustular, large black scabs are formed, and the characteristic odour of smallpox, which can be detected even in the discrete form of the disease, becomes sickening in the extreme. The mucous membranes of the mouth, larynx, and trachea are involved, and there is huskiness of voice and difficulty in swallowing. In severe cases it takes several weeks before desquamation is complete, while in both forms of the disease it may be laid down as a safe rule that no patient should be pronounced free from infection until all the pustular crusts have fallen off, and the whole surface of the body has been well sponged with warm water and some disinfectant soap, or several warm baths have been taken.

The stage of the disease at which the poison is first generated in the person of the sick has not been accurately determined, but there cannot be the slightest doubt that

so soon as a case is diagnosed or suspected, precautionary measures should forthwith be adopted. Unfortunately, however, it sometimes happens that isolated cases of the disease are mistaken for cases of chicken-pox or German measles. In my own district I have had to investigate several outbreaks in which errors in diagnosis of this description have been made, and I have also been consulted in a few cases when the disease turned out not to be smallpox, as suspected, but either chicken-pox or measles. Of course it is often very difficult to diagnose with certainty isolated cases of any one of these diseases, and hence it is very essential that not only should the character of the eruption be carefully scrutinised, but the premonitory and other symptoms, as well as the probable source of infection, should also be inquired into. Above all, the arm should be examined as regards the character of the vaccination marks, if any. In cases of modified smallpox showing good vaccination marks, the papules are often not only sparse, but soon abort and disappear; and I have seen a very characteristic outbreak of this modified form of the disease among workhouse children, in which there was no difficulty in accounting for the outbreak, or in deciding as to the nature of the disease. In chicken-pox the premonitory symptoms are slight; the papules, which generally appear first on the trunk and shoulders, become converted into vesicles on the second day, and dry up about the fourth. The vesicles are usually globular in form, translucent in appearance, have no central depression, and collapse on pricking. Smallpox vesicles, on the other hand, are flat and circular in form, always depressed in the centre, and, being multicellular in structure, do not collapse on pricking. Moreover chicken-pox is much more a disease of early childhood. If smallpox is prevalent in the neighbourhood, any case presenting symptoms which are assumed to be

those of chicken-pox should be regarded with suspicion, and especially if the patient is an adult. Smallpox is occasionally ushered in by eruptions which simulate those of measles, scarlatina, or erysipelas; but if the disease be smallpox, the eruption will show characteristic features within twenty-four hours, or will show signs of malignity. Of eruptions unattended by general symptoms, acne, erythema, and urticaria are sometimes mistaken for smallpox, but mistakes of this kind may in most cases be avoided by a careful consideration of the history of the case.

The precautionary measures to be taken so soon as a case of smallpox is diagnosed are briefly these:—The patient, if not at once removed to a hospital, should be carefully isolated, and the house quarantined as far as possible. All persons living in the same house or adjoining houses, over twelve years of age, unless protected by previous attack of smallpox, should at once be re-vaccinated, and likewise all children whose vaccination marks are not large and distinct. The details concerning the hygiene of the sick-room and disinfection will be described in the following section, while the official instructions with regard to vaccination and re-vaccination are given in the Appendix.

2. *Measles* is more especially a disease of early childhood, and is highly infectious. The contagium may be conveyed by *fomites*, or by means of the contaminated air of the sick-room, and readily clings to surfaces. The period of incubation is from ten to twelve days, rarely a day or two more. The eruption appears on the fourth day after the febrile and catarrhal symptoms set in, and consists of a deep red-spotted rash, appearing first on the face and forehead, and afterwards on the trunk and extremities. The rash is at first slightly raised, and is distributed in crescentic groups, which extend over all parts

of the surface. It persists as a general mottling after subsidence of the fever, and in severe cases may be followed by a fine desquamation. The constitutional symptoms seldom set in until eight days after exposure to infection, and generally consist of fever more or less intense, aching pains, and vomiting, followed by some signs of coryza, cough, and sneezing. The eruption lasts three or four days, and generally fades in the same local sequence as it appeared. In very mild cases there may be slight rash without catarrh, or catarrh without eruption. In the severe type of the disease, known as black measles, there is generally hæmorrhage from the mucous surfaces, and death may occur before the rash is thrown out.

The disease usually prevails as an epidemic, and it very rarely attacks a person more than once. When it breaks out in a school or family it is sure to spread—the catarrhal stage, which is infectious throughout, being often mistaken for a cold, so that no precautionary measures are adopted. After an attack personal infection is probably over by the end of the month, although it may persist longer. How long infection may cling to articles of clothing or linger in close rooms is uncertain. The average proportion of deaths to attacks in this country is from 10 to 12 per cent, and more than one-half the total number of deaths are of children under two years of age. Owing to the catarrhal nature of the disease the fatality is increased by cold weather and on damp soils.

German measles, rötheln, or *rubella* is now recognised to be a distinct specific disease, and though one attack generally protects against subsequent attacks, it does not protect against an attack of rubeola or common measles. The period of incubation is longer than measles, mostly a fortnight. It is not so infectious as measles, nor are the symptoms so severe; but, like measles, it is a disease of

childhood, though adults are liable to be attacked. The sudden appearance of the rash without any marked premonitory symptoms distinguishes it from measles. There may be slight coughing and sneezing, but within a few hours or a day after attention has been aroused the rash on the face begins to make its appearance. The rash consists of discrete spots or blotches, from the size of a pin's head to that of a bean, round or oval, and of a pale rose-red colour, slightly raised above the skin, with a distinct, or at times, a faded border. After appearing on the face, these spots and blotches may also be seen on the neck and thighs, but less frequently on the forearms and lower parts of the leg. The size of the spots or blotches is less than those of measles, while their form is more round and their colour paler. The eruption lasts two days, and then disappears without any desquamation. Infection persists for a month.

The precautionary measures indicated as regards common measles or German measles are isolation of the patient, careful attention to the hygiene of the sick-room, disinfection of clothing, bedding, etc., preventing children from infected households mixing with other children; and if outbreaks threaten to become severe the question will arise, especially in rural districts, whether closing of schools may not be deemed necessary.

3. *Scarlatina or Scarlet Fever.*—The invasion of scarlet fever is usually abrupt, the temperature beginning to rise at once and seldom preceded by rigors. The premonitory symptoms are slight languor, restlessness, vomiting often, and sore throat. The fever is characterised by suffusion of the eyes, flushing of the face, and difficulty in swallowing. The lymphatic glands at the angles of the jaw become enlarged and tender, and already the palate and tonsils are red and inflamed. Very often a fine flush of redness suffuses the neck and chest soon

after the throat symptoms are complained of, and the eruption may thus be among the earliest signs of the disease. It generally appears by the second day, and is well marked on the third, or it may be delayed, suppressed, or recede. When well-marked the eruption begins on the neck, face, and chest, and soon spreads to the trunk and limbs. It is characterised by fine red points, closely spread over a large surface, leaving no clear skin between. They are not raised above the widely-diffused flush, and momentarily disappear under pressure of the finger. The eruption reaches its fullest extension by the fourth day and begins to fade on the fifth and sixth. Desquamation usually begins from the sixth to the ninth day, and, according to the severity of the attack, may take five to six, or even eight weeks in completion, the palms of the hands and soles of the feet being last to peel.

The period of incubation is usually from three to four days; it may be only a few hours, and it may possibly extend to seven days. The longest clear interval from a single definite exposure has been four and a half days.

There are three recognised varieties of the disease, namely, scarlatina simplex, scarlatina anginosa, and scarlatina maligna; but the shorter classification into scarlatina mitior and scarlatina gravior is preferable. In scarlatina mitior the symptoms may be so mild that they attract little or no notice, and it may be three, four, or five weeks before the shreddy look of hands or toes betrays the true nature of the illness. There may be sore throat with little or no rash, or well-marked rash with slight sore throat. It is these mild cases which often play such havocs in school outbreaks, especially in country districts. The first cases are often so slight that no medical attendant is called in, nor are any precautions taken, when suddenly severe cases crop up, all of them traceable

to infection through school-agency, and the school has to be closed.

Scarlatina gravior includes all the more serious cases, either designated as scarlatina anginosa, when the throat symptoms are the most dangerous; or scarlatina maligna, when the high fever and its consequences are marked from the first. Between these two types and the slighter forms of the disease there are all grades of severity, and the latter often proves rapidly fatal, before even the rash appears. In the former type the throat symptoms often present a diphtheritic appearance.

Although scarlet fever may attack persons of all ages, it specially attacks children between the third and fourth year; after the fifth year the chances of attack decline rapidly, and as a rule a previous attack confers permanent immunity from the disease. Taken generally the proportion of deaths to attacks is about ten per cent.

As regards the period of infection there is no doubt that the disease is infectious so soon as throat symptoms set in, and before the eruption appears, but, according to my own experience, it is seldom that other cases break out in the same family if the first case is promptly removed to a hospital, and proper steps are taken to disinfect the house, etc. The patient ought not to be pronounced free from infection until desquamation has entirely ceased, and the whole surface of the body has been well bathed, nor so long as there is any discharge from secondary abscesses. During the febrile stage, and when desquamation sets in, the contagium, like that of smallpox, is exceedingly powerful and volatile, so that no susceptible person can remain in the same room for any length of time, or even in the same house, unless the patient is carefully isolated, without running great risk of contracting the disease. Moreover, the contagium is contained in everything which proceeds from the patient, but more especially in the

cuticular scales given off in desquamation. These scales, laden with the specific poison, are conveyed by the currents of air to every part of the room, and may settle on clothing, bedding, furniture, walls, etc. They preserve their virulence for an unknown period of time, and when disturbed are always liable to reproduce the disease. Thus, there are several instances recorded in which the fever has been contracted by sleeping in a room which weeks previously had been occupied by a scarlet fever patient; and the fact that the poison adheres to articles of clothing is proved by instances in which the disease has been propagated by the clothing of pupils returning home from school, clothing sent home from infected laundries, or clothing received from infected houses where tailoring or sempstress work is done. The cases already referred to in the chapter on food are also of great interest in showing the absolute necessity of the utmost care and cleanliness to be observed on all occasions, whether the attack is mild or severe. Indeed where milk-supplies are concerned the dangers of spreading the disease through the agency of milk have often received painful illustration, and, according to a report of Mr. Power concerning an outbreak of scarlet fever in Hendon and Mary-le-bone, presented to the Local Government Board in March this year, there can be little doubt that milk may not only convey infection, but that cows are found to suffer from a similar disease, and that the milk of these cows is directly productive of the disease. It has long been surmised that pet animals may be the medium of conveying infection in outbreaks of scarlatina; but the fact that cows suffer from a similar disease is quite a new discovery, and one which, if confirmed, must open up a wide field for further efforts in prevention.

The precautionary measures which are indicated by the above remarks are obvious, although it may be ad-

mitted that it is impossible to carry them out efficiently in the crowded homes of the poorer classes. But even in homes where no difficulty should be experienced, the necessary isolation and disinfection are too often grossly neglected, either because they are irksome, or, if the case is slight, because they are considered to be needless. With regard to special precautions, see Appendix.

4. *Diphtheria.*—This disease was not recognised under its present name in this country till about the year 1859, though there is no doubt that under various names it has prevailed in many countries from the earliest times as croup. It was first accurately investigated by M. Bretonneau about the year 1821. Although the etiology of the disease still continues to afford ample room for research, there can be little doubt that in its origin and spread it is often intimately associated with sanitary defects. It is more or less endemic in certain localities, and frequently prevails as an epidemic. Although it is not hereditary, there is no doubt that certain individuals and families evince a great susceptibility when exposed to infection, or to causes which are likely to produce the disease.

Diphtheria is specially characterised by the exudation of a tough false membrane on the soft palate, tonsils, pharynx, larynx, or trachea. This membrane, which is generally of a grayish white colour, may appear on any one or all of these parts, or it may appear in the vulva, vagina, or anus, or on a wound or ulcer. In the vast majority of cases, however, it is found on the mucous surfaces of the throat or air-passages, and generally commences on the tonsils. From thence it may spread in different directions, backwards and upwards into the posterior nares, or downwards into the larynx and trachea. The submaxillary glands usually become enlarged, and owing to the extension of the disease difficulty in swallowing and breathing are common symptoms. There

is generally great prostration of strength from the first, and in very severe cases the poison sometimes kills before any local symptoms are manifested.

With regard to the period of incubation there is great diversity of opinion, but there are good grounds for believing that in the great majority of cases it does not exceed a few days, probably not more than three. The invasion of the disease is generally occult and insidious. Three or four days may be passed without any characteristic signs being observable, when suddenly the disease explodes with an attack of stridulous breathing, and on examining the throat the characteristic exudation is then seen. It is often exceedingly difficult to diagnose between diphtheria, ulcerated sore throat, croup, and some types of scarlatina. Indeed in outbreaks of diphtheria cases presenting the characteristic features of all these diseases are to be met with,—slight ulcerated sore throat, large and inflamed tonsils with patches into the pharynx and croupous extension into the lungs, and skin eruptions suggestive of scarlatina.

It is always safe to regard a patchy throat accompanied by prostration and no symptoms of scarlatina, if not diphtheritic, as certainly infectious. Moreover, these patchy or ulcerated throats are so frequently associated with sanitary defects that they are often spoken of as drain throats.

Among the sequelæ of the disease there is generally albuminaria as in scarlatina, and paralysis of various parts, more particularly of the soft palate, which often comes on after apparently complete recovery, or during the course of the acute malady. A striking feature in this form of paralysis is the changed character of the voice and its distinct nasality, a feature which is occasionally of great value in inquiring into outbreaks of diphtheria, when early cases may have been regarded as cases of ulcerated sore throat.

According to Dr. Thursfield, medical officer of health of the Shropshire Combined District, diphtheria is associated with dampness of dwellings, and in this respect may, like ague, be largely preventible by the improvement of local conditions. In most cases the severity of the disease is directly influenced by the conditions under which the person attacked is living; and the symptoms become greatly intensified by the disease passing through a person who has newly come into the locality. It is more prevalent in rural than in urban districts, and although it may attack adults, it is, like scarlatina, a disease of childhood and early youth. When once the disease becomes developed it is eminently infectious, the contagium being given off principally from the throat and breath, although there can be little doubt that it is also conveyed by the other excretions, and may thus become disseminated through the agency of sewers or closets. In a household and among children, it is often disseminated by kissing, and, indeed, the greatest care ought always to be taken not to bend over the patient, so as to inhale the breath. Further, there can be no doubt that the infection is most portable, and may be conveyed in articles of clothing and the like, but the opinion that it may be wafted long distances in the air does not appear to be corroborated, although certain atmospheric conditions would appear to favour the extension of the disease. As in enteric fever, the disease may be spread through the agency of contaminated milk; and, according to Dr. Thursfield, the infection can be taken from a corpse, or, at least, from its adjuncta. Of all diseases, not even excepting scarlatina, this is the one most liable to be disseminated through the agency of schools, partly because the symptoms are frequently so mild as not to prevent children from attending school, but chiefly because the disease is peculiarly liable to be spread by the breath, and may be

disseminated by the throat after children are sent back to school apparently well. The greatest care ought therefore to be exercised not only in keeping children from infected houses from attending school, or mixing with others, but in not allowing those children who have been attacked to return to school until all symptoms of debility and relaxed condition of throat have disappeared. The other precautions to be taken are much the same as those recommended with regard to scarlatina (see Appendix).

Brief reference may here be made with regard to *croup* (not spasmodic).—There is considerable divergence of opinion concerning the definition or etiology of this disease, for while some writers, such as West, regard croup as acute inflammation of the larynx or trachea, followed by exudation on the inflamed surfaces, other writers, such as Johnson and Rose Cormack, following the French school, regard this as diphtheria. These hold that membranous exudation is never a result of simple acute inflammation, and this, so far as causation and sanitary precautions are concerned, is no doubt the proper view to take. So-called croup with exudation should therefore be regarded as diphtheria.

5. *Whooping-cough.*—This is an infectious specific disease, characterised by a peculiar spasmodic cough, of about six or eight weeks duration, and chiefly affecting children and young infants. Indeed three-fourths of all the deaths attributable to it occur among children under two years of age.

The period of incubation varies from four to ten days, and one instance is given of a fortnight. Usually some catarrhal or febrile symptoms, with or without cough, appear from the fourth to the seventh day after exposure. This stage lasts a week, and the whoop mostly begins about ten days after the ingress of the disease; but there is great irregularity both in the stages and in the severity

of the symptoms. The cough is paroxysmal and very characteristic, the inspiration being attended by a peculiar crowing sound. Three weeks may elapse before children exposed to infection manifest the whoop, and they should therefore not be allowed to mix with others who are susceptible until this period is safely over. The disease is highly infectious, and the contagium is readily conveyed by *fomites* and by the clothes of those in attendance on the sick or who may visit them. Active infection is given off by patients only slightly affected, or who are only in the early stage of the disease, and continued till some time after the characteristic symptoms have disappeared. The disease is largely spread by "neighbouring" and by school agency, and, as in the case of measles, by an utter disregard of any proper precaution in the way of isolation or the like. Indeed the prevalence of these two diseases is in great measure attributable to the culpable neglect, arising from the popular belief, amounting almost to fatalism, that children must contract them some time, and that there is therefore little use in endeavouring to take any protective steps when either disease is epidemic. The consequence is that the epidemic continues to spread so long as susceptible victims are to be found in the community, and only dies out for a time when almost all these have been attacked. How far the medical profession are to blame in allowing this popular delusion to retain its hold on the public mind it would be difficult to say; but until they unite in striving to get rid of the listless apathy which it engenders, the prevalence of such epidemic diseases will continue to be an opprobrium to sanitary science.

6. *Fever.*—The continued fevers are generally understood to be typhus, enteric, and relapsing fever; or they are classified, as in the returns of the Local Government Board, as typhus fever, enteric fever, and other or doubtful forms of fever.

(1.) *Typhus Fever.*—This fever has prevailed since the earliest times, and has been variously known as putrid, pestilential, ship, or jail fever. It is an infectious febrile disease, marked by a peculiar dark mulberry-looking rash, accompanied by considerable cerebral depression, and usually lasts three weeks. It is eminently a disease of the poor, and is intimately associated with destitution and over-crowding. Except in the rookeries of our large towns, it is now a disease of comparatively rare occurrence, and cases are seldom met with in rural or small urban districts.

The period of incubation has not been accurately determined, but on the average it is probably about a week. The disease is ushered in by languor, dulness of all the senses, and fever. The mottled dusky eruption, especially noticeable over the abdomen, generally makes its appearance during the later half of the first week. During the second week the symptoms increase rapidly in intensity until the fourteenth day, when the disease appears to have attained its height. With the third week the general symptoms begin to improve, the rash quickly disappears, and by the end of the week the attack may be said to have terminated.

Although not so infectious as smallpox or scarlatina, the disease is undoubtedly contagious, the contagium being thrown off by the cutaneous and respiratory exhalations. But the contagium does not travel far through the air, and it appears that if a patient can be isolated in a large well-ventilated room, there need be no difficulty in preventing the disease from spreading in the household. But as typhus is liable to break out in dirty and over-crowded localities, such isolation can only be secured by prompt removal to a hospital.

(2.) *Enteric or Typhoid Fever.*—This has been defined as a continued fever of long duration, usually attended with diarrhœa, and characterised by peculiar intestinal

lesions, a scattered eruption of small rose-coloured spots, and enlargement of the spleen. As pointed out in Chapter I. it was not recognised as a special disease until about the year 1848.

That this disease is essentially a filth-disease is alike admitted by those who accept the doctrine of Von Gietl and Dr. Budd, and those who, like the late Dr. Murchison and Sir William Jenner, maintain that it may be generated independently of previous cases. As it occurs in rural and small urban districts, my own experience leads me to believe that the great majority of scattered cases, and many of the first cases of isolated outbreaks, are due to poisoning of air, drinking-water, or other ingesta with decomposing filth. Most frequently it is found that the well-water has become polluted by soakage from some drain, cesspit, or manure heap, and in some instances it would appear as if ill-defined forms of enteric fever, such as those vaguely termed low fever, gastric fever, febricula, and the like, may be caused by decomposing organic matter not necessarily fæcal. But whether the disease is produced by befouled air or polluted water, there is a constantly accumulating amount of evidence which goes to prove that neither the air nor the water need be tainted with the specific contagium of the disease. At the same time, there is no fact more clearly established in preventive medicine than this,—that whenever the disease is developed, the bowel discharges possess an infective power, which, where local conditions assist, can operate with terrible force, and often at long distances from the sick. It is rarely transmitted from person to person, but in crowded dwellings there is no doubt that there is great risk of its spreading if the evacuations and soiled clothing and bedding are not carefully disinfected and strict cleanliness attended to. In country districts it is frequently propagated by throwing the excreta into common privies

or ash-pit middens, and in several towns it is generally spread through neglect to disinfect the excreta before throwing them down the closet, and thereby specifically polluting the sewer-air.

Any epidemic of enteric fever in a sewered town points to imperfect ventilation, deficient-flushing, or to faulty construction of sewers or drains, or to contamination of the water-supply, as in the outbreaks described in Chapter VIII., or to polluted milk, as in the outbreaks referred to in Chapter II. In villages and country districts it points to polluted wells, bad drainage, or filthy privies and cesspools, all of which may originate the disease in the first instance, as well as be the means of propagating the specific contagium when it is developed or introduced.

The period of incubation is not definitely known, but in the majority of cases it is probably about twenty-one days, though in some instances which have been recorded the disease has set in immediately after exposure to intensely foul emanations from sewers or cesspools which have been opened. But the invasion is almost always insidious, and the initial symptoms vague. The temperature affords the most conclusive evidence of the disease if it is carefully watched. It rises progressively from day to day, and is usually a degree or two higher in the evening than in the morning. The bowels at first may be confined or relaxed, but towards the close of the first week there is generally more or less tenderness in the right iliac fossa, and the abdomen becomes more or less tumid. The characteristic spots may be detected sometimes as early as the fourth or fifth day of the fever, but usually they do not appear until a week or more has elapsed, and in a considerable proportion of cases they are absent altogether. They are pinkish in colour, about the size of a pin's head, slightly raised and pointed, disappear

on pressure and reappear when the pressure is removed. They are usually few in number, distributed irregularly over the abdomen and chest, and appear in successive crops, the duration of individual spots lasting about four days. If the case is distinguished by diarrhœa, it is at this period that it becomes most troublesome. The motions have a most offensive odour, are copious, liquid, rather pale in colour, and have a "pea-soup" appearance. Later on, when ulceration of the intestines has set in, they may become bloody, but hæmorrhage only occurs in about 8 per cent of the cases. In typical cases there is enlargement of the spleen. The disease reaches its height at the end of the third week, and the tendency to recovery is usually indicated by lowering of the temperature and abatement of the other symptoms. Relapses, however, are common, and convalescence in all cases protracted.

The principal precautions to be taken have already been indicated, but in addition to using disinfectants for the excreta and soiled linen it is advisable to pour boiling water over them.

Cases of fever, of an undefined type, are to be met with in all outbreaks of enteric fever, and as a rule the scattered cases which crop up in rural and small urban districts are cases of this description. They are undoubtedly pythogenic, and the disease may be fairly designated "filth fever." Such cases are variously returned as low fever, fever, febricula, and gastric fever, and, like enteric fever, may spread through neglect to disinfect and properly dispose of the ejecta by burying them in a hole dug in the ground, whenever possible. As already stated these isolated cases of fever are generally found to be associated with polluted well-water or filth nuisances.

(3.) *Relapsing Fever.*—This is a continued infectious fever without any special eruption, and characterised by a

tendency to relapse at intervals of from five to seven days, and generally occurring as an epidemic. It is essentially a disease engendered by famine or scarcity of food, and during recent years has become very rare in this country.

Other kinds of fever, such as intermittent and remittent fevers, are diseases of malarial origin. Intermittent fever, or ague, is now seldom met with in this country, and remittent or jungle fever, as it is commonly called, is especially a disease of hot climates, while yellow fever is more particularly confined to the West Indies, America, and Africa.

6. *Diarrhœa.*—Although many are inclined to dispute the grounds on which diarrhœa is classed as a zymotic disease, there is abundant evidence to prove that wherever it becomes prevalent it is due in large measure to insanitary conditions, and that so-called summer diarrhœa is often as distinctly infectious as enteric fever. No doubt there is a considerable amount of diarrhœa which is due to hand feeding, to errors in diet, and to the putrefactive changes which are set up in milk and other articles of food owing to want of cleanliness during times of increased heat, but the outbreaks in Leicester and other large towns go to prove that the polluted air from sewers, made-up soils, and other filth accumulations, assume a specially infective power during very hot weather, and investigations have shown that the tainted air is largely infested with bacteria. As in the case of enteric fever, diarrhœal discharges infect the air of sewers and, in country districts, the air of privies and cesspits. School closets if not kept properly scavenged are very liable to spread the disease.

Choleraic diarrhœa is characterised by the suddenness of its onset, and is often accompanied by vomiting. The stools are at first feculent, but speedily become watery and colourless. Severe cases followed by collapse have

sometimes been mistaken for Asiatic cholera, but the fluids from the stomach and bowels are seldom free from bile, and are not so like rice-water as in true cholera.

Dysentery is usually characterised by fever, tormina, and tenesmus, and frequent scanty mucous evacuations tinged with blood.

7. *Cholera.*—True Asiatic cholera is a specific disease characterised by the suddenness of its onset, by violent vomiting and purging, cramps, rice-water stools, collapse, and a tendency to run a rapidly fatal course. As has just been pointed out, cases of choleraic diarrhœa are sometimes mistaken for true cholera, and no doubt the symptoms are often very similar, but in the absence of any sufficent reason to suspect cholera it is wise to reserve a decided opinion so as not to arouse needless alarm. Precautions should, however, be taken to disinfect the ejecta.

Asiatic cholera was unknown in Europe before the year 1829, although it had prevailed in India for many centuries. It would be out of place here to discuss the various theories which have been advanced concerning the propagation or pandemic extension of the disease. Koch's views with regard to the specific nature of the so-called "comma bacilli" have not yet received that amount of confirmation to warrant their general acceptance, indeed they are warmly contested by Klein and others. Pettenkofer's views have already been referred to in Chapters VIII. and XIII., and certainly have not been confirmed by the researches of those who have studied the disease in this country;—suffice it to say that the conclusions originally arrived at by Dr. Snow in 1854 (see Chapter VIII.), and since then more fully illustrated and enforced by Mr. Simon, have been generally accepted, and that they alone explain on a true sanitary basis the propagation of the disease in the several epidemics which

have been carefully investigated in England and Wales. Mr. Simon's views are briefly these :—"That the quality of infectiveness of the disease belongs especially, if not exclusively, to the matters which the patient discharges by purging and vomiting from the intestinal canal; that these matters are comparatively non-infective at the moment when they are discharged, but subsequently, when undergoing decomposition, acquire their maximum infective power; that choleraic discharges, if cast away without previous disinfection, impart their own infective quality to the excremental matters with which they mingle, and to the effluvia which these matters evolve; that if the cholera-contagium by leakage or soakage from drains or cesspools, or otherwise, gets access, even in small quantity, to wells or other sources of drinking-water, it infects, in the most dangerous manner, very large volumes of the fluid; that in the above-described ways even a single patient with slight choleraic diarrhœa may exert a powerful infective influence on masses of population among whom perhaps his presence is unsuspected; that things, such as bedding and clothing, which have been imbued with choleraic discharges, and not afterwards fully disinfected, may long retain their infectious properties, and be the means of exciting choleraic outbreaks wherever they are sent for washing or other purposes."—(*Eighth Report of the Medical Officer of the Privy Council.*)

With regard to special precautions against the infection of cholera, see Appendix.

Having thus far considered in detail the principal zymotic diseases, a few words may now be added by way of summary concerning *channels of infection.* And first it has to be pointed out that diseases such as scarlatina, measles, diphtheria, and whooping-cough, which especially attack young children, are almost invariably spread through the agency of schools. Not only are children from in-

fected houses allowed by their parents to attend school so long as they are not prohibited by public officials or the medical attendant, but it often happens that children who are only affected to a slight extent with one or other of these diseases are permitted to go to school as usual, and thus become certain and dangerous centres of infection. But apart from the disastrous results which depend upon the ignorance or reckless indifference of parents in this respect, there can be no doubt too that the agency of schools in the propagation of infectious diseases is becoming all the more potent as attendance becomes better enforced. It is often urged by teachers and school managers that it is no use closing schools to check the further spread of infectious disease, because the children are sure to mingle and play together out of doors. But the conditions are altogether different. In the open streets there is far more free space, and there is comparatively little risk of inhaling infections from the breath and clothes; whereas at schools the children's caps, bonnets, shawls, and overcoats are hung up together; the children themselves are packed so closely while in school that they must inhale each others' breaths, and have to run all the risks of personal contact; while the dangers are frequently increased by the condition of the outside offices, which in country districts especially are often of the foulest description and notoriously neglected.—(For Official Memoranda concerning the closing of public elementary schools, see Appendix.)

Among other channels by which infectious disease is frequently spread may be mentioned the occurrence of cases in small shops, or other places of business. Under such circumstances, an attempt is generally made to conceal any cases of the kind as long as possible, because the shopkeeper is afraid of losing his business and frightening his customers. Then too, there can be little doubt that in-

fectious disease is often spread by tailors and sempstresses, who are allowed to stitch the garment of the fashionable wearer in their own miserable homes, where perhaps a sick child suffering from scarlet fever, measles, diphtheria, or whooping-cough lies covered with rags in a corner of the same room. Indeed, in London and other large towns, there is very little of the actual work of fashionable tailoring or millinery establishments done on the premises; the large bulk of it is taken home by the work-people and finished there. But there are other channels of infection which operate perhaps even more disastrously than these, and amongst them may be mentioned the following:—Pawn-shops, where articles of clothing from all parts and mostly from insanitary homes are huddled and stored together; small laundries, which are scattered round the outskirts of towns; dairymen's premises, when they are not properly supervised and kept in order; and lodging-houses in fashionable health-resorts. People who live in clean and elegant houses, away from the foul breeding places of infectious diseases, are too apt to forget how closely the dangers press upon themselves, for not only may their clothes be made in these pestiferous localities, but servants, charwomen—"the hewers of wood and drawers of water"—who attend to their wants, either live in the over-crowded slums of our large towns, or have friends or relations whom they visit there. It thus appears that infectious diseases take advantage of almost every relationship of life. The infective material may be left in a cab, communicated in a railway carriage, or be actually inhaled from the breath or infected clothing of the person sitting next one in an omnibus or tramway car.

The wider channels of infection, such as water-supplies and public sewers, have already been fully illustrated, while recent inquiries go to prove that domesticated animals play a far greater part in the propagation of infectious diseases than has hitherto been suspected.

CHAPTER XV.

Disinfectants and Disinfection

It has been sufficiently illustrated in the previous chapter that of all agencies for preventing the spread of communicable disease cleanliness is one of the most important. Whenever there is prevalence or threatening of epidemic disease it is of the utmost importance that the statutory powers conferred upon Sanitary Authorities for the protection of the public health should be promptly and efficiently carried out. Nuisances should be removed; scavenging well attended to; sewers kept well-flushed, ventilated, and disinfected; water-supplies examined and protected; cleanliness of premises enforced; over-crowding abated; and thorough ventilation secured.

It is a cardinal principle in disinfection that it should be carried out at the source, or as near the source of the infection as possible. Discharges from the mouth, nose, and bowels, as well as the urine, should be received into vessels containing some disinfectant, and be thoroughly incorporated with solutions of the same disinfectant before they are removed. In cases of smallpox or scarlatina, inunction of the skin with some suitable preparation, such as carbolised oil, will do much to protect the air from cuticular infective material. Soiled articles of clothing or bed-linen should be at once steeped in boiling water with or without previous disinfection, and always when possible boiled afterwards.

Section I.—Disinfectants.

In the strict sense of the word, a disinfectant may be defined as any agent which destroys or renders inert the contagium of any specific disease. The term, however, has been so vaguely applied that it has been made to include any agent which possesses deodorising, antiseptic, or fixative properties.

Without entering into any discussion on the *modus operandi* of disinfectants generally (because the subject is still under dispute), it will be convenient for practical purposes to enumerate and describe the most useful amongst them *seriatim*, and without any attempt at classification.

1. *Heat and Cold.*—While extreme cold prevents putrefactive change, and therefore acts as an antiseptic, extreme heat is destructive of all organic matter, and in this respect it is the most efficacious, as it is the most ancient, of all disinfectants. But even a temperature much below that of actual combustion is found to be sufficiently powerful, if continued for any length of time, to kill animal or vegetable germs, and to render inert any contagious matter. Thus, the late Dr. Henry proved experimentally that the vaccine virus was deprived of the power of reproduction when exposed for three hours to a temperature of 140° Fahr., while a temperature of 120° failed to produce this effect. As a result of these and other experiments, he was the first to recommend the employment of the hot-air chamber to disinfect clothing, bedding, and the like. These experiments have been further extended by various observers, and notably by Dr. Baxter, Dr. Koch, and more recently and exhaustively by Dr. Parsons. (See *Annual Report of the Medical Officer of the Local Government Board*, for 1884.) As Dr. Parsons' most valuable report has been published separ-

ately and distributed by the Local Government Board to Medical Officers of Health throughout the country, it will be sufficient here to indicate very briefly the basis and methods of procedure, and the principal conclusions derived from them. In the first place it was necessary to determine by experiment what was the special virus or contagium which was the most resistant to every form of heat, and after trying the virus of swine-plague, tuberculosis, and anthrax,—all of which admit of being tested on animals before and after exposure to various degrees of heat,—Dr. Parsons and Dr. Klein, who was associated with him in the inquiry, satisfied themselves that the virus of anthrax was the most resistant. Having settled this point, they were able to proceed on the assumption that such apparatus or arrangements as would yield a heat sufficient to destroy the anthrax virus, not only in its bacillar but in its spore form, might be relied upon to destroy the potency of infectious matter generally. In experimenting upon the efficiency or otherwise of the various kinds of apparatus which have been constructed for this purpose, it was seen to be necessary that the heat generated should penetrate bulky and non-conducting articles, while at the same time it would not injure or destroy the most delicate fabrics. Dr. Parsons' main conclusions are briefly these:—

(1.) It may be assumed that the contagia of the ordinary infectious diseases of mankind are not likely to withstand an exposure of an hour to dry heat of 220° Fahr., or one of five minutes to boiling water or steam of 212° Fahr.

(2.) Dry heat penetrates very slowly into bulky and badly conducting articles, as of bedding and clothing, the time commonly allowed for the disinfection of such articles being insufficient to allow an adequate degree of heat to penetrate into the interior.

(3.) Steam penetrates far more rapidly than dry heat, and its penetratration may be aided by employing it under pressure, the pressure being relaxed from time to time, so as to displace the cold air in the interstices of the material.

(4.) When dry heat is used, scorching begins to occur at different temperatures with different materials, white wool being soonest affected. It is especially apt to occur when the heat is in the radiant form. To avoid risk of scorching, the heat should not be allowed to exceed 250° Fahr., and even this temperature is too high for white woollen articles.

(5.) Steam disinfection is inapplicable in the case of leather, or of articles which will not bear wetting.

(6.) For articles that will stand it, washing or steeping in boiling water may be relied on as an efficient means of disinfection. It is necessary, however, that before boiling, the grosser dirt should be removed by a preliminary soaking in water. This should be done before the linen leaves the infective place.

(7.) The objects for which disinfection by dry heat or steam is especially applicable are such as will not bear boiling in water, *e.g.*, bedding, blankets, carpets, and cloth clothes generally.

(8.) The most important requisites of a good apparatus for disinfection by heat are (*a*) that the temperature of the interior shall be uniformly distributed; (*b*) that it shall be capable of being maintained constant for the time during which the operation extends; and (*c*) that there shall be some trustworthy indication to the actual temperature of the interior at any given moment.

(9.) In dry heat chambers, and more especially those heated by coal or coke, the first requirement is very often far from being fulfilled, and in very few of them did the thermometer with which the apparatus was provided

afford a trustworthy indication of the temperature of the interior.

(10.) In steam apparatus, the three requirements above mentioned are all satisfactorily met, and for this reason, as well as for the great rapidity and certainty of action by steam, Dr. Parsons holds that steam chambers are greatly preferable to those in which dry heat is employed.

(11.) It is important that the arrangement of the apparatus, the method of working, and the mode of conveyance to and fro should be such as to obviate risk of articles which have been submitted to disinfection coming into contact with others which are infected.

(12.) After carefully experimenting with various new apparatus and others employed by sanitary authorities in different parts of the country, Dr. Parsons, without wishing to give the preference to any one maker over another, mentioned the following as giving the best results of any in their respective classes :—Of the apparatus heated by coal, the newer machine, patented by Bradford and Co., Salford, Manchester ; of those heated by gas, the Nottingham self-regulating apparatus, invented by Dr. Ransome, F.R.S., and manufactured by Messrs. Goddard and Massey, Nottingham ; and of those employing steam, Lyon's patent steam disinfector, manufactured by Messrs. Manlove, Alliot, and Co., Nottingham.

When no proper apparatus is available for disinfecting bedding and woollen articles, the best substitute is disinfection by sulphurous acid in a closed room, taking care that the hair of mattresses is well teased out, and that the various articles are hung over ropes stretched across the room. This should be done in the room which has been occupied by the patient when the room has to be disinfected and purified. Woollen articles should be steeped in a strong solution of carbolic acid (1 in 20),

but all articles which can stand boiling water should be boiled.

2. *Sulphur Dioxide* or *Sulphurous Acid Gas.*—This is exceedingly useful for disinfecting empty rooms. It is obtained by burning lumps of sulphur in an earthenware pipkin, or other vessel that will not readily crack. Usually fumigation is best effected by burning about 1 lb. of lumps of sulphur for every thousand cubic feet of space, and in a long room it is advisable to burn the sulphur in one or more places, in order to ensure thorough disinfection. One pound of sulphur, when burned, produces 11 cubic feet of sulphurous acid gas. It is advisable to support the vessel containing the sulphur on a pair of tongs over a bucket of water, to obviate risk of burning the floor. The various steps in disinfecting the sick chamber will be described further on.

According to Baxter, sulphur dioxide destroys the activity of dry vaccine on points very rapidly, and even when much diluted, stops the amœboid movements of living cells, kills vibrios, and acts as a powerful deoxidising agent.

3. *Chlorine* decomposes sulphuretted hydrogen and ammonium sulphide, and possesses such a strong affinity for hydrogen that it readily breaks up compounds containing that body. It has been recommended for the disinfection of empty rooms, but it is not so efficacious nor so practicable as sulphur dioxide. When employed for this purpose, it is most readily obtained in one of the following ways :—(1.) To equal parts of common salt and binoxide of manganese add two parts of water, and about the same amount of strong sulphuric acid. (2.) To one part of powdered binoxide of manganese add four parts by weight of strong muriatic acid. (3.) To three parts of bleaching powder add one part of strong sulphuric acid. In any case, the quantities required will depend

upon the size of the room. Whether chlorine or sulphur dioxide be chosen, it is desirable that the place to be disinfected should be kept saturated with the gas for at least two hours.

4. *Nitrous Acid* fumes are obtained by adding strong nitric acid, diluted with a little water, to copper filings. The power of oxidising organic matter possessed by nitrous acid is very great, and no disinfectant will more readily remove the offensive smell of the dead-house. The fumes, however, are exceedingly irritating and dangerous. It has been highly recommended as a disinfectant for infected byres and pig-styes.

5. *Carbolic Acid.*—For steeping clothing, this is perhaps the best disinfectant. For fine articles a solution of the pure crystals (1 in 20) should be used, but for ordinary purposes, a solution of the crude acid (1 pint to 2 gallons of water) will suffice. As the crude acid has been productive of several fatal accidents on account of its having been mistaken for porter or other liquids, the carbolic acid powder is safer for use in the sick-room. It can be employed in scrubbing out floors, in steeping clothes, and in vessels for receiving the excreta. It is also very useful in disinfecting urinals, latrines, water-closets, stables, midden-heaps, etc. In whatever form it is used, the acid is destructive of the low forms of animal and vegetable life, and arrests or prevents all kinds of putrefactive change. It should never be freely sprinkled around the sick-room, on account of its irritating and disagreeable odour.

6. *Potassium Permanganate.*—This substance is non-poisonous, and is a good deodoriser, but it is too expensive for general use. Condy's fluid, red and green, is a solution of this substance, and is a very suitable deodorant for the sick-room.

7. *Chloride of Lime* is very useful for disinfecting

drains and cesspools, and possesses the advantage of being cheap and manageable.

Amongst numerous other agents which have been highly recommended are *sanitas* and terebene, both well-suited as deodorisers for the sick-room; M'Dougall's powder, sulphate of copper, Burnett's solution, and Jeye's disinfectant, for drains, cesspits, etc., and charcoal for filth accumulations.

Although the list might be considerably extended, the most reliable are heat, boiling water, sulphurous acid, and carbolic acid, but whatever agents are used, care should be taken that they do not neutralise each other; for example, carbolic acid decomposes Condy's fluid and chlorine.

Section II.—Practical Disinfection.

1. *Hygiene of the Sick-room.*—In all cases of highly infectious disease, if the patient is not removed to a hospital, the first duty to be attended to is the enforcement of a strict domestic quarantine by isolation of the patient whenever it is possible; the next point is to make certain that the room is well lighted and sufficiently ventilated by means of open windows, and fires if necessary; and the third point is to require the instant removal of all extraneous furniture, such as carpets, curtains, and the like. The attendant on the patient should receive strict and precise injunctions, not only with regard to the nursing of the patient, but also with regard to the maintenance of the utmost cleanliness in the room, the disinfection of excreta, slops, soiled linen, etc., and their immediate removal afterwards; and other points of detail depending upon the special nature of the disease and the circumstances of the patient.

Although aerial disinfectants may be regarded as of

doubtful efficacy in the sick-room, they are deemed to be useful or expedient by many; and, when properly selected and managed, it may be said, at all events, that they do not do any harm, if they are not productive of much good. The great danger is, that when employed without due precaution, they may only serve to disguise the signs of insufficient ventilation, and in this way conduce to inattention as regards this most essential point. If they are employed at all, they should not be irritating to the patient. Hanging rags steeped in disinfectant solutions about the room is not to be commended, but a sheet moistened with a strong solution of carbolic acid, sanitas, or Condy's fluid, and suspended outside the door of the room is very useful to complete the isolation of the patient, and sweeten the air of the room. The infected clothing, etc., should be received into a tub containing a solution of carbolic acid or some other disinfectant, and the ejecta, etc., should be instantly covered with the particular disinfectant used, and removed. Further, the inunction of the body of the patient, in certain of the exanthematous infectious diseases, and especially scarlet fever, with camphorated oil, or a mixture of terebene and sweet oil, or a weak solution of glycerine and carbolic acid, followed by disinfecting baths during convalescence, is attended with the best results.

2. *Disinfection of Empty Rooms and Uninhabited Places.*—After a case of infectious disease, the room should be thoroughly cleansed and disinfected. The furniture should be washed with some disinfectant soap, the room, as far as possible, emptied, and the paper removed. After closing doors, windows, and other openings, sulphurous acid gas should be generated in large quantities in the manner already described, and the room kept closed for several hours. After this, the door and windows should be thrown open, the ceiling should be washed with

quick-lime and whitened, the walls repapered, and the floor and wood-work thoroughly washed with water and some disinfectant soap.

3. *Disinfection of Clothing, Bedding, etc.*—Any material of this description which cannot be injured by being washed, should be steeped in a solution of carbolic acid, and boiled. If Condy's fluid be used, the material should merely be immersed, and afterwards rinsed out in cold water, otherwise the solution will stain. In all cases, however, when it can be carried out, the clothing, bedding, etc., are best disinfected by heat, and for this purpose every town of any dimensions should be provided with a disinfecting apparatus for public use. In connection with every such apparatus in large towns there should be a covered van or hand-cart for conveying infected articles, and great care should be taken, by the free use of disinfectants, or by wrapping the articles in a sheet moistened with a strong disinfecting solution, to prevent any risk of spreading disease.

The hair of infected mattresses should be teased out, fumigated, and exposed to the air, if the mattresses cannot be disinfected in a hot-air chamber. Rags and other articles which can be spared should be destroyed by fire, but so as not to create nuisance. When clothing cannot be disinfected by heat, Dr. Ransome has proposed that the different articles should be placed, layer on layer, in a box, with hot sand or bricks placed at the bottom, and sprinkled over with carbolic acid; but a better plan is to hang them up in a small room and disinfect them with sulphurous acid gas.

4. *Disinfection of Water-Closets, Urinals, Sinks, etc.*—In any district where an epidemic prevails or is threatening, disinfection of all sewers, drains, etc., should be carried on systematically. Some disinfectant, such as carbolic acid, or Jeye's fluid, might be used in water-carts for the

streets, lanes, and open courts. Any manure-heaps or other accumulations of filth, which it is inexpedient to disturb or impossible to remove, should be covered with a layer of fresh dry earth, or with freshly-burnt lime. Cesspits and midden-heaps should also be disinfected. It need hardly be said, however, that in a town or district well looked after by the sanitary authorities, no such filth-accumulations would be allowed to take place at any time.

5. *Disinfection of the Dead Body.*—When a patient dies of a highly infectious disease, such as smallpox or scarlatina maligna, the body should be washed with a very strong solution of carbolic acid, or, better still, enveloped in a sheet saturated with such solution, and placed in the coffin as soon as possible, disinfectants being again freely used, and the lid screwed down. The burial should take place without delay; or in crowded districts, and in towns where a mortuary is provided, the dead body should be at once removed thither. The linen worn by the patient at death, if not buried with the body, should be destroyed by fire; but when this cannot be done without creating nuisance, the burning should be effected at some distance from houses, or the bedding may be saturated with quick-lime, and buried.

It may be urged that many of these directions are needlessly minute, and that, in fact, they cannot possibly be carried out in perhaps the great majority of cases. In answer to such objections let it be said, once and for all, that no labour is wasted which aims at preventing the spread of disease, even though it be often attended with failure; and that, however limited be the means or opportunity of carrying out preventive or precautionary measures, such means and such opportunity should always be used, so as to be productive of the

best possible results under the circumstances. Although a number of disinfectants have been mentioned, it is always advisable that only a few, and those deemed the most efficient, should be used. For more special directions, see Appendix.

CHAPTER XVI.

VITAL STATISTICS

VITAL statistics may be defined as the science of figures applied to the health-history of communities. They deal with the principal events or phenomena of human life,—the births, marriages, and deaths; the various diseases from which people suffer or die, together with all the influences which affect vitality. In other words, the units of which they are composed consist mainly of persons living and of persons dying, and these units are classified or grouped under certain definite characteristics, such as age, sex, occupation, and disease. The analysis of these units or elementary facts, observed in their various relations to time and place, and dealt with according to strict numerical method, lies at the foundation of all sound inquiry, and supplies the only true criterion of sanitary progress.

SECTION I.—SOURCES OF INFORMATION.

In briefly discussing this subject, for the purposes of the health officer or sanitarian, it will be convenient to refer at the outset to the two main sources from which the data which constitute vital statistics are derived, namely, the census returns, and the returns of births, marriages, and deaths, supplied by registration. As all these returns particularise the locality of every unit, whether supplied

by census or registration, the units themselves can be readily classified according to various divisions or sub-divisions of the country, such as counties, towns, unions, parishes, villages, or streets, or according to urban and rural districts, as defined by the Public Health Act, 1875. For purposes of registration the country is divided into registration and sub-registration districts, which bear a more or less definite relation to counties, towns, and unions; while for sanitary purposes the particular returns, which apply to every district, however small or however large, can be obtained by every sanitary authority throughout the country from the district registrars. The management of the census, and the entire charge of the vital statistics of the United Kingdom, are entrusted to three Registrars-General, viz. one for England and Wales, one for Scotland, and one for Ireland, who publish yearly and quarterly reports for the whole country, and weekly reports for certain large towns.

1. *The Census.*—The census, or actual enumeration of the people, is effected in Great Britain every ten years. The first enumeration was made on 10th March 1801, and the last on 4th April 1881, so that the recent census was the ninth enumeration of the inhabitants of this country. In order to secure accuracy of returns it is essential that the census should be taken rapidly and simultaneously; and this is effected by issuing schedules to every householder beforehand, who has to enter all the particulars concerning every one sleeping in the household on the night of the date fixed for the census. These schedules are all scrutinised and collected on the following day by the appointed enumerators, and in due course forwarded to the office of the Registrar-General, where they are tabulated and made available for statistical purposes.

It need hardly be said that the taking of a census

does not consist merely of a simple enumeration of the people. Amongst other items, the schedule returns contain particulars of the name, sex, age, rank, profession or occupation, condition, relation to head of family, and birthplace of every living person who passed the night of the date of the enumeration in every house throughout the kingdom. When these returns are fully classified and analysed, they not only give the number of inhabited and uninhabited houses in every parish, town, union, or county throughout the kingdom, together with the number of inhabitants, but the population can be grouped according to age, sex, occupation, etc., thus supplying a vast storehouse of statistical information, which is of the highest value.

The following table, from the Preliminary Report of the 1881 Census, is interesting, as showing the growth of the population of England and Wales, and the enormous increase in the population of London, during the present century :—

Year of Enumeration.	Population in England and Wales and in London at the Nine Enumerations.		
	England and Wales.	London.	Persons in London to 100 in England and Wales.
1801 . . .	8,892,536	958,863	10·78
1811 . . .	10,164,256	1,138,815	11·20
1821 . . .	12,000,236	1,378,947	11·49
1831 . . .	13,896,797	1,654,994	11·91
1841 . . .	15,914,148	1,948,417	12·24
1851 . . .	17,927,609	2,362,236	13·18
1861 . . .	20,066,224	2,803,989	13·97
1871 . . .	22,712,266	3,254,260	14·33
1881 . . .	25,968,286	3,814,571	14·69

The aggregate population of England and Wales at the last census, including the population of London, consisted of 12,624,754 males and 13,343,532 females, show-

ing an excess of females over males of 718,778. Further, it is shown that the rate of increase in the aggregate population is almost entirely dependent upon two factors, namely, the birth-rate and the death-rate; the effects of emigration, immigration, or other movements of the population, being found to be comparatively insignificant. The rapid growth of the past decennium was also ascertained on analysis to be due to the fact that the birth-rate was unusually high, while the death-rate was much below the average. This is shown in the following table, which applies to England and Wales:—

	Mean Annual Birth-rate.	Mean Annual Death-rate.
1841-1851 . .	32·61	22·33
1851-1861 . .	34·15	22·25
1861-1871 . .	35·24	22·50
1871-1881 . .	35·35	21·27

In the words of the report, "the higher birth-rate in 1871-81, as compared with the preceding decade, implies the addition of 26,774 extra members to the community; while the lower death-rate implies the survival of 299,385 persons who, with the previous rate of mortality, would have died."

What is called "the natural increment of the people" is represented by the excess of births over deaths, while the "actual increment" can of course only be determined by enumeration. During the last decennial period the difference between the natural and actual increment only amounted to 0·74 per cent, the former representing an increase of 15·08 per cent upon the population at the beginning of the period, while the latter represented an increase of 14·34 per cent.

The following table gives the population of the United Kingdom at the censuses of 1851-81 inclusive:—

——	1851.	1861.	1871.	1881.
United Kingdom. .	27,745,949	29,321,288	31,845,379	35,246,562
England	16,921,888	18,954,444	21,495,131	24,608,391
Wales	1,005,721	1,111,780	1,217,135	1,359,895
Scotland	2,888,742	3,062,294	3,360,018	3,734,370
Ireland	6,574,278	5,798,967	5,412,377	5,159,839
Isle of Man . . .	52,387	52,469	54,042	53,492
Channel Islands . .	90,739	90,978	90,596	87,731
Army, Navy, and Merchant Seamen abroad.	212,194	250,356	216,080	242,844

2. *Calculated Estimates of Population.*—Having pointed out so much concerning the actual census of the people, it becomes necessary now to refer to the method of estimating populations adopted by the Registrar-General for years intervening between one census enumeration and the next. This method of calculation is based, as regards the country generally, and large and growing populations, on the assumption that the rate of increase which prevailed between the last two census enumerations will be maintained until the next census is taken. The estimate of the population of a town or sanitary district thus obtained becomes the basis upon which the birth-rate, death-rate, and other rates are calculated, and it need hardly be said that the nearer the estimate approaches the actual number of the population the more strictly reliable will be the statistical results. The method pursued by the Registrar-General requires the use of logarithms, and is lucidly described in a leading article in the *Sanitary Record Diary* for 1886. In the article in question the population of Sheffield is dealt with by way of illustration, and this is stated as amounting to 239,946 at the census of 1871, and 284,508 at that of 1881, giving an increase of 44,562 persons during the intervening period. The article then goes on to show that "the rate of increase can most conveniently and most simply be

calculated by the aid of logarithms. Instead of taking the difference between the population enumerated in 1871 and 1881, the difference between the logarithms of these numbers affords the true method for ascertaining the *rate of increase.* The logarithm of the population of Sheffield in 1871 is 5·3801136, and that of the population in 1881 is 5·4540945; the difference between these logarithms is 0·0739809, which is the logarithm of the rate of increase of population in Sheffield during the ten years 1871-81. If this logarithm of the rate of increase be added to the logarithm of the population in 1881, the number corresponding to this new logarithm will be the estimate of the population at the next census in 1891, which would on this basis be 337,346 (or 52,838 more than the enumerated population in 1881). Having obtained the logarithm of the ten years' increase (0·0739809), a tenth of this will give us the logarithm of the annual rate of increase; by inserting a cypher to the left of the logarithm, we shall divide it by 10, and 0·0073981 will be the logarithm of the annual rate of increase. The Registrar-General usually estimates his populations, for calculation purposes, to the middle of the year, and as the census is taken at the end of March or the beginning of April, a quarter of the logarithm of the annual rate has to be added to the logarithm of the enumerated population to obtain the logarithm of the estimate for the middle of the year 1881. The logarithm of the annual rate in Sheffield divided by 4 gives 0·0018495, which, added to the logarithm of the enumerated population in 1881, gives the logarithm of the population in the middle of 1881, namely, 5·4559440. Having thus obtained the logarithm of the population in the middle of 1881, the successive addition thereto of the logarithm of the annual rate of increase (0·0073981) will give the logarithm of the population in the middle of 1882, 1883, and so on.

The addition of three and a quarter times the logarithm of the annual rate of increase to the logarithm of the enumerated population of Sheffield in 1881 gives the logarithm 5·4781383, the number to which is 300,703; this is the correct estimate of the population of the borough of Sheffield in the middle of 1884.

"The reverse operation—that is, deducting the logarithm of the annual rate of increase from the logarithm of the estimated population in the middle of 1881—will give the logarithm of the population in the middle of 1880; and by repeating this operation the logarithm of the populations in the middle of each of the years back to 1871 may be obtained."

In small and slowly-increasing districts the following method of calculation will give a fairly approximate estimate of the population. Add to the population of the district as enumerated at the last census a tenth of the difference between that number and the number obtained at the previous census for each year that has elapsed since the last census. This will give the estimated population for the end of the first quarter of any given year, that being the period of the year at which the census is taken. But inasmuch as the death-rate is calculated on the estimated population of the district at the close of the second quarter or middle of any year, it is evident that a fourth part of the annual increment, or a fortieth part of the actual increase, of population which has taken place between the two censuses must be added to represent the increment for the additional quarter.

As regards new and rapidly-increasing districts, however, this method of calculation will not apply; and in such cases it is desirable, when possible, to ascertain the number of inhabited houses for the year, which may generally be obtained from the assessment books. An approximately correct estimate of the population can then

be obtained by multiplying the average number of inhabitants per house, which can be ascertained from the last census returns, by the number of occupied houses.

3. *Registration.*—Ever since the days of Queen Elizabeth, births, deaths, and marriages have been registered in the different parishes throughout England; but it was not till the year 1837 that the Legislature passed an Act which provided that for the future all these entries should find a place in a national register, and that as regards deaths the various causes or diseases should be certified by the medical attendant. That the important office of the Registrar-General of England, which was established by that Act, has been productive of a vast amount of benefit to the health of the nation, and indeed has largely stimulated other countries to follow in the wake of sanitary progress, there can be no doubt. The first Annual Report of the Registrar-General, which was drawn up by the late Dr. Farr, appeared in 1839, and from the date of his appointment as Superintendent of the Statistical Department up to the date of his retirement in 1879, his was the master-mind which, by a wide yet accurate induction from statistical data, laid the foundations of public hygiene, and at the same time enlarged and established the principles of medical science.

In England and Wales there are over two thousand registrars and superintendent-registrars, whose duty it is to collect and forward to the central office at Somerset House all the certificates returned to them throughout the country. These, as already stated, apply to births, marriages, and deaths.

a. Registration of Births.—The chief data in these returns are the sex, the date of birth, the place of birth, the number of births (twins or triplets), legitimacy, and the residence of the parents.

b. Registration of Marriages.—These returns give the

name, age, occupation, residence, and condition of husband and wife.

c. Registration of Deaths.—The principal data in these returns are the date, name, residence, age, sex, occupation, condition (whether single, married, or widowed), and the fatal disease or cause of death.

In the case of children the age is stated in days, weeks, or months up to two years. But of all the data the most important to the hygienist is the cause of death, which has to be certified by the medical attendant, or, in cases of inquest, by the coroner. To ensure accuracy of statistical results it is highly essential that the cause of death should be clearly diagnosed, and certified according to the nomenclature of diseases drawn up by the Royal College of Physicians, and adopted by the Registrar-General. But it must be confessed that, apart from errors in diagnosis, which frequently occur, the cause of death is too often certified in a haphazard sort of way, and with but little regard to correct medical terminology. As a rule, however, these inaccuracies apply for the most part to causes of disease which do not come under sanitary control; and in this respect, therefore, they do not vitiate statistical results to any appreciable extent, except when the primary cause of death is not certified. For example, a case of enteric fever often succumbs to pneumonia; a case of scarlatina to nephritis; a case of measles or whooping-cough to bronchitis; a case of phthisis to diarrhœa; a case of rheumatic fever to endo-carditis—and so on. Now, in all such cases it is of the utmost importance that the primary cause should be certified as well as the secondary, because the former is the cause which should be classified as the actual cause of death. Accuracy of data, uniformity of data, and completeness of data, are all of them indispensable to correct statistical analysis.

But, in addition to the registration of deaths, it has

long been urged by leading sanitary reformers, that no true estimate of the vitality of the nation can be formed, unless a national system of registration of cases of sickness is also established. It is true that to a certain limited extent this has been attempted by the Local Government Board, by issuing instructions to clerks of unions to furnish weekly returns of all new cases of sickness occurring among paupers, whether in-door or out-door, to the medical officers of health of their respective districts; but the information thus supplied is often of a very incomplete kind, and, except as regards cases of fever or infectious disease, is practically of little value. Of far greater importance is it for purposes of sanitary defence that some system of compulsory notification of all cases of dangerous infectious disease should be adopted for the country generally, such as is now in force in several large towns, because without prompt information of early cases, preventive measures are often of little avail, and especially in districts where proper hospital accommodation has been provided.

Section II.—Classification.

The data thus obtained are classified or grouped under various headings. For example, so far as the duties of the medical officer of health are concerned, the births are classified according to sex, while the deaths are classified according to sex, ages, and diseases. In large urban districts the system of classification usually adopted is that of the Registrar-General, but for small urban or rural districts the limited tabular returns required by the Local Government Board will be sufficient. In either case, however, printed forms should be used for classification, and arranged to contain all the data for weeks, months, or quarters.

In classifying data of any kind, it is essential that

the individual units should have precise and definite characters, so that every unit in a group should be strictly included in that group. Then, again, the dividing character of every group should be so distinct and clearly defined as to afford no room for doubt under which group or heading every unit should be classified. Care also should be taken that no unit should be classified so as to appear in two allied groups at the same time. Thus, we will suppose that a death has been returned as due to phthisis as the primary, and diarrhœa as the secondary, cause: it would obviously vitiate the results if the single case were classified under the heading of diarrhœa, and also under that of phthisis.

Section III.—Statistical Results.

After the data or units have been correctly classified, it becomes possible to compare and discuss their numerical relations. For this purpose a constant numerical standard must be adopted, and in vital statistics it is the rule to state this relation or rate as so much per cent or per 1000, or some other multiple of 1000.

1. *Birth-Rate.*—The birth-rate of a population or community is obtained by comparing the total number of births occurring in a year and the total population estimated, as previously shown, at the middle of the same year. It is usual to represent it as a rate per 1000 of the population living in the district, at all ages. Thus we will suppose that the estimated population of a district is 11,902, and that the number of births registered in the district during the year amounted to 384, then the birth-rate is obtained as follows:—

$$11{,}902 : 1000 : : 384 : X,$$

or annual birth-rate per 1000

$$= \frac{384 \times 1000}{11{,}902} = 32{\cdot}2.$$

The birth-rate in England and Wales in 1885 was equal to 32·5 per 1000 persons estimated as living at the middle of the year. The rate of illegitimate births is generally represented as a percentage of the total number of births, or it may be represented per 1000 persons living. Taking the whole of England and Wales, and neglecting decimals, one child out of twenty is born out of wedlock. Thus, the total number of births registered in England and Wales during 1880 amounted to 881,643, of which number 42,542 were born illegitimate, being in the proportion of 4·8 to every 100 children born.

Male births are everywhere more numerous than female, but in England and Wales the proportion of boys to girls is smaller than in any other European country.

The high birth-rates which prevail in large urban districts are in great measure due to the fact that the marriage-rate is higher, and that women marry younger than they do in country districts; while another cause which no doubt operates to a considerable extent is the high rate of infant mortality, thus shortening the intervals of child-bearing, by the early deaths of the new-born. In fashionable towns, where large numbers of unmarried servants are employed, and where a large proportion of the residents are retired people, the birth-rate is always very low.

2. *Marriage-Rate.*—This, like the birth-rate, is usually calculated as a rate of persons marrying per 1000 of the population living in the middle of the year. The average marriage-rate in England and Wales during the ten years 1871-80 was 16·1 per 1000.

3. *Mortality.*

(1.) *Total Annual Death-rate.*—What is called the general death-rate, or total annual death-rate, of any district or community, is determined by means of a ratio between the number of deaths occurring during the year and the estimated population in the middle of the year,

and, like the birth-rate, is represented as a rate of so many deaths per 1000 of the estimated population. Thus, we will suppose that the estimated population of a district amounts to 22,151, and that the number of deaths which occurred in the district during the year amounted to 335, then the total annual death-rate would be calculated as follows :—

$$22{,}151 : 1000 : : 335 : X,$$

or

$$X = \frac{335{,}000}{22{,}151} = 15{\cdot}1,$$

where X represents the total annual death-rate per 1000.

The following table shows both the recorded and the corrected rates of England and Wales from 1838 onwards :—

MEAN ANNUAL DEATH RATES.

Years.	Recorded Death-rate.	Corrected Death-rate.
1838-40	22·33	22·65
1841-45	21·38	21·61
1846-50	23·32	23·41
1851-55	22·66	22·75
1856-60	21·80	21·77
1861-65	22·58	22·46
1866-70	22·42	22·25
1871-75	21·96	21·87
1876-80	20·82	20·71
1881	18·88	18·88
1882	19·56	19·57
1883	19·54	19·54

The death-rate in England and Wales in 1885 was 19·0 per 1000 persons estimated to be living at the middle of the year.

In the great majority of sanitary districts with comparatively small populations, the total annual death-rate does not represent the *actual* death-rate, and corrections must be made for deaths of persons not belonging to the

district, which occur in hospitals, workhouses, asylums, or among visitors, and for the deaths of persons belonging to the district which occur outside the district. Take, for example, the statistics of a town of some 10,000 inhabitants in the centre of a union of some 45,000 inhabitants. The town is a separate sanitary district, but contains the workhouse for the whole union. It is evident that the death-rate for the town would be represented as larger than it really is if no correction were made for the deaths which occur in the workhouse; while, on the other hand, the death-rate of the surrounding rural district would appear less than it actually is, unless the quota of in-door pauper deaths belonging to it is added to the total number of deaths. To make these corrections, the statistics of deaths occurring in these institutions, giving full particulars of age, sex, and residence, must be obtained. In populous urban districts, however, if the number of deaths occurring amongst strangers be not excessive, they may fairly be included in calculating the death-rate, because in this case they may be considered as fairly representing the deaths of those persons belonging to the district who have died elsewhere.

So far, then, the problem of calculating the annual death-rate of any town or district becomes a very easy matter when the statistics are summarised for a whole year. But in respect to some large towns it is customary for the health officer to publish weekly, monthly, or quarterly reports; and as all the rates given in these reports are calculated as annual rates per 1000 of the population living in the middle of the year, the problem becomes considerably more complicated. When monthly reports are submitted some medical officers of health calculate the annual rates by taking five weeks for the months of March, June, September, and December, and four for the other months; but this method, though convenient, is not

strictly accurate, and it is much preferable to adopt the method pursued by the Registrar-General. This is so fully and clearly described in an article which appeared in the *Sanitary Record* of August 1875, that it may be fitly quoted here :—

"In the first place it is scarcely necessary to say that all the rates now published by the Registrar-General, whether they relate to a year, a month, or a week, are annual rates to 1000 persons living ; that is, these published rates represent the number of persons who would die in the year in 1000 of each population, if the proportion of deaths to population recorded in the shorter periods of a week, or a month, or a quarter, were maintained throughout a whole year.

"Let us take a rate of mortality from the Registrar-General's last weekly return relating to the seven days ending July 31 as an example. We find in Tables 1 and 2 of that return it is stated that the estimated population of the borough of Sheffield in the middle of 1875 is 267,881 persons ; that 127 deaths were recorded within the borough during the week under notice ; and further, that these deaths were equal to an annual rate of 24·7 per 1000 of this estimated population. Now for the operation by which this result is arrived at. We have the deaths in a week, and the estimated population in which they occurred ; it is desired to find the number of the deaths which would occur in each 1000 of this population, if the same number of deaths were recorded in each week throughout a year. If a week were the correct fifty-second part of a year, it is obvious that either the deaths must be multiplied by fifty-two, or the population be divided by fifty-two, in order to make the population and the deaths comparable. As, however, the correct number of days in a natural year is 365·24226, the number of weeks in a year is 52·17747. The Registrar-General, therefore, for the purpose of this weekly return, divides the estimated population of each of the towns dealt with by 52·17747, which gives what may be called the weekly population of each town. The population of Sheffield divided by 52·17747 gives a weekly population of 5134 persons ; this number serves as constant throughout the year 1875, by which to divide the number of deaths. The 127 deaths in Sheffield during the week ending July 31, divided by this so-called weekly population, gives an annual rate of 0·0247 to each person of the population ; and by removing the decimal point three places to the right, or in other words multiplying by 1000, we arrive at 24·7, which is the correct annual rate

of mortality per 1000 of the estimated population of the borough of Sheffield during that week. It would undoubtedly be more logical to multiply the deaths by 52·17747 than to deal with the population ; but this operation would have to be repeated each week, whereas there is a manifest convenience, and an arithmetical economy, in the reverse operation (the effect of which is, of course, identical), which supplies us with a constant that is applicable throughout the fifty-two weeks of 1875. For all practical purposes the multiplication of the deaths in a week by fifty-two, in order to divide them by the estimated population, will afford the means of arriving at an approximately correct annual rate of mortality ; or the reverse operation, the division of the population by fifty-two, may be resorted to.

"For the calculation of annual rates of mortality in a month or a quarter the Registrar-General takes account of the number of days in each month or quarter, and it is found more convenient to deal with the population according to the method described in the calculation of the annual rate of mortality in a week. The populations to be dealt with are divided by 365·24226, and must then be multiplied by the number of days in a month or a quarter, in order to arrive at the population which may be applied to the deaths in a month or a quarter ; by this means a scientifically correct annual death-rate in those respective periods will be obtained. Approximately correct annual rates of mortality in a month or a quarter may be calculated by using a twelfth or a quarter of the population respectively, as the divisor of the number of deaths recorded in those periods ; but, inasmuch as the length of a month varies from twenty-eight to thirty-one days, and of a quarter, from ninety to ninety-two days, it is evident that a correct annual rate of mortality can only be calculated by taking into account this variation in the number of days in those periods, and that rates calculated without correction for these inequalities will differ from the rates published by the Registrar-General.

"In conclusion, it may be noted that rates published in the quarterly returns of the Registrar-General for the eighteen largest English towns relate to the period of thirteen weeks most nearly corresponding with the natural quarter, and that the population employed in this calculation is thirteen times that used for the rates in each week, and differs slightly from the population that would be used if the period of observation were three entire calendar months instead of thirteen weeks. The facts published in the quarterly return for all other parts of the country, except the eighteen largest English towns, relate to the natural quarters of three calendar months, and the population used to produce the annual rates of mortality therein are manipulated in the manner before described."

The following table is interesting as showing the gradual and progressive decline in the death-rates of both urban and rural districts throughout England and Wales, and how greatly the urban have been gaining on the rural districts as regards healthiness :—

URBAN AND RURAL DEATH-RATES AT SUCCESSIVE PERIODS.

YEARS.	MEAN ANNUAL DEATH-RATES PER 1000 LIVING.		
	Urban Districts.	Rural Districts.	Rural Rate below Urban Rate.
In 4 years 1847-50	26·9	20·6	23·4 per cent.
In 10 years 1851-60	24·7	19·9	19·4 ,,
In 10 years 1861-70	24·8	19·7	20·6 ,,
In 10 years 1871-80	23·1	19·0	17·7 ,,
In the year 1880	21·9	18·5	15·5 ,,

In addition to the birth-rate and death-rate, the other rates which are generally given in the reports of medical officers of health are the death-rate from zymotic disease and the rate of infant mortality.

(2.) *Zymotic Death-Rate.*—What is called the death-rate from the seven principal zymotic diseases, or zymotic death-rate, is based on the total number of deaths occurring in a district during the year due to smallpox, measles, scarlatina, diphtheria, whooping-cough, fever (typhus, typhoid, and other or doubtful forms of continued fever), and diarrhœa. This, like the birth-rate or total annual death-rate, is calculated on the estimated population of the district, and is expressed as so many per 1000. Thus, we will suppose that in an estimated population of 22,438 the deaths from the seven principal zymotic diseases amounted to 48 during the year; the zymotic death-rate in this instance would be :—

$$\frac{48 \times 1000}{22{,}438} = 2{\cdot}1 \text{ per } 1000.$$

According to the returns of the Registrar-General, the mean annual death-rate from the seven principal zymotic diseases in England and Wales in the three decades 1851-60, 1861-70, and 1871-80 was 3·87, 4·11, and 3·36 per 1000 respectively, while during the five years 1881-85 it has fallen to 2·40.

The annual death-rate from any other group of diseases, or from any single disease such as fever or phthisis, is calculated in the same way as the zymotic death-rate. Thus, the number of deaths attributed to "fever" which occurred in England and Wales during 1885 amounted to 5657; and as the estimated population at the middle of the year was 27,499,041, the death-rate from fever was—

$$\frac{5657 \times 1000}{27,499,041} = 0{\cdot}21 \text{ per } 1000.$$

In the three most recent decades it was equal to 0·91, 0·89, and 0·48 per 1000 respectively, thus showing a most marked decline.

(3.) *Rate of Infant Mortality.*—The rate of infant mortality, in the returns of the Registrar-General and in most health reports, is measured by the proportion of deaths of infants under one year to births registered, and is expressed as so many per 1000 births. Thus, we will suppose that the total number of deaths of children under one year of age which occurred in a given district amounted to 112 during the year, and that the births registered during the year amounted to 898, the rate of infant mortality estimated in this way will therefore be—

$$898 : 1000 : : 112 : X,$$

or

$$X = \frac{112 \times 1000}{898} = 124.$$

The annual rate of infant mortality in England and Wales for 1885 was equal to 138 per 1000 registered

births, while the average rate for the ten years 1871-80 was 149 per 1000.

(4.) *Death-Rate at various groups of Ages.*—The death-rate of children under five years of age is sometimes expressed as a percentage of the total number of deaths, or it may be expressed as a rate per 1000 of the estimated number of children under five years living in the middle of the year. This estimate, like that of the population of a district, is calculated on the total number of children living under five years, as actually enumerated at the two last censuses, and published in the census reports. In the same way, the death-rate among persons of any given age is calculated from the estimated population living at that age, or the mortality per 1000 persons living may be stated according to groups of ages. This is illustrated in the following tables from the Supplement to the Forty-fifth Annual Report of the Registrar-General.

AGE-DISTRIBUTION OF POPULATION (PERSONS) OF ENGLAND AND WALES. (Mean of 1871 and 1881.)

All Ages.	Age-Periods.										
	Under 5	5–	10–	15–	20–	25–	35–	45–	55–	65–	75 and upwards.
1000	136	120	107	97	89	147	113	86	59	33	13

AVERAGE ANNUAL DEATH-RATE PER 1000 LIVING, AT ALL AGES, AND AT ELEVEN GROUPS OF AGES, DURING 1871-80.

All Ages.	Under 5 years.	5–	10–	15–	20–	25–	35–	45–	55–	65–	75 and upwards.
21·27	63·12	6·43	3·70	5·33	7·04	8·93	12·62	17·72	31·49	64·85	161·59

(5.) *Death-Rate of Persons engaged in various Occupations.*—According to Dr. Farr, "the only way in which

the mortality and the duration of life of miners, tailors, farmers, labourers, or any other class of men can be accurately determined is to determine the ratio of deaths at each age to the living during a certain time—in fact, to apply the same method to each class as is applied to determine the mortality and the mean lifetime of all classes in a town, in a district, or in the whole kingdom." The Supplements to the Thirty-fifth and Forty-fifth Reports of the Registrar-General contain a vast amount of statistical information bearing upon this important subject, showing to what extent the nature of the occupation influences mortality.

(6.) *Death-Rates in Different Localities.*—The general death-rate of the population is an average of high and low death-rates. High death-rates prevail in large towns and low death-rates in country districts, while in large towns it is found that the death-rate varies enormously in different parts. According to Dr. Farr, the mortality of districts increases with the density of their population; but density of population is a complex condition, implying a combination of many separate morbific agencies, social and sanitary, which can only be ascertained by analysing and comparing statistical results, and especially with regard to age-distribution. Thus, the fashionable suburbs of large towns inhabited by the wealthy classes always contain a great excess of adults of the ages in which low death-rates prevail, while the birth-rate is also low. In the poorer and more crowded localities, on the other hand, there are no servants kept, and the birth-rate is high, so that the much higher mortality among infants and young children, compared with that of the adult population, raises the death-rate of the population to which they belong. But even when due allowance is made for age-distribution, it is found that the mortality in all the crowded parts of large towns is much higher at nearly all ages, and especially during childhood, adolescence, and

the productive period of life, than in the better circumstanced and more salubrious suburbs.

(7.) *Mortality in relation to Seasons.*—In estimating the significance of statistical results, no correct inferences can be drawn unless due attention is paid to the important influence of weather changes. Generally speaking, it may be said that during winter there is a predisposition to diseases of the respiratory organs, and that any fall below the mean average temperature is followed by an increased sick-rate and death-rate from these diseases. During summer, on the other hand, intestinal disorders become more prevalent, and any rise above the mean average temperature will be followed by an increased sick-rate and death-rate from diarrhœa and filth diseases generally. As a rule, the mortality is highest in the first quarter of the year and lowest in the third,—the order from highest to lowest being first, fourth, second, third,—but in many districts this sequence is found to vary considerably, and indeed, it is found to vary in respect to the country generally, as the following table will show :—

Years.	Annual Death-rates per 1000 living in the Quarter ending the last day of			
	March.	June.	September.	December.
1870-79	24·1	21·1	19·8	21·6
1880	22·7	19·6	20·3	19·5

4. *Longevity.*—This term may be used to embrace various statistical expressions, to which brief reference may be made, such as—

(1.) *Mean Age at Death.*—The mean age at death of the population is obtained by dividing the sum total of the ages at death by the number of deaths. It is a very

fallacious indication of longevity, and affords no true test of sanitary condition, because it fluctuates very largely, according to the varying proportions of young and old lives in different districts. In districts where the birth-rate is high the mean age at death will be comparatively low. The mean age at death of an entire generation alone gives accurately the mean duration of life, and this is determined by life-tables. According to Dr. Farr's life-table, which was based upon the census and mortality returns 1838-54, the mean age at death of an English generation was 40·86 years. But inasmuch as the population of England is not stationary, but always rapidly increasing, by reason of the excess of births over deaths, the mean age at death of all who died during the years 1838-54 was 29·4 instead of 40·86. These averages have been supplemented by Mr. Humphreys, in a most valuable paper read before the Statistical Society of London (see *Sanitary Record*, May and June 1883), in which he discusses the whole bearings of improved sanitation, as evidenced by the recent decline in the English death-rate, and its effect upon the duration of life. According to Mr. Humphreys' new life-table, based upon the last census returns and the mortality returns of 1876-80, the mean age at death of an English generation is raised to 43·56 years, while the mean age at death of persons dying in the five years 1876-80 was found to be about 32 years. In respect to sex, the mean age at death of males, according to Dr. Farr's life-table, was 39·91 years, and of females 41·85 years; while according to Mr. Humphreys' new life-table, the former has risen to 41·92 years, equal to an addition of 5 per cent to the mean duration of the lifetime of males, and the latter to 45·25 years, representing an addition of over 8 per cent to the average lifetime of all females born.

It may here be explained that in constructing these

life-tables, the calculations are based on a hypothetical generation of a million persons, consisting of the same proportion of males and females at birth and at subsequent ages, which is found to exist in the general population, and on the numbers of each sex dying each succeeding year, until the whole generation becomes extinct.

(2.) *Expectation of Life or mean after-lifetime at various ages.*—The expectation of life, calculated for years or groups of ages, represents the portion of future life which an individual at any age may reasonably expect to enjoy; and this, like the mean age at death or mean duration of life, is given in life-tables. Such tables afford the best means of testing the vitality of communities. The following life-table, given by Mr. Humphreys in the paper already referred to, not only shows clearly how the recent decline in the English death-rate has affected the mean duration of life in this country, but how it has affected the mean after-lifetime at various ages:—

Mean After-Lifetime (*Expectation of Life at various Ages*) *from Life-Tables based upon English Mortality* in 1838-54 *and* 1876-80.

Ages.	Persons.		Males.		Females.	
	1838-54.	1876-80.	1838-54.	1876-80.	1838-54.	1876-80.
0 . . .	40·86	43·56	39·91	41·92	41·85	45·25
5 . . .	50·02	52·56	49·71	51·47	50·33	53·65
10 . . .	47·36	49·24	47·05	48·16	47·67	50·32
15 . . .	43·54	45·05	43·18	43·94	43·90	46·15
20 . . .	39·88	40·98	39·48	39·86	40·29	42·10
25 . . .	36·57	37·21	36·12	36·05	37·04	38·36
35 . . .	29·99	30·01	29·40	28·88	30·59	31·12
45 . . .	23·41	23·29	22·76	22·34	24·06	24·21
55 . . .	16·94	16·75	16·45	16·09	17·43	17·37
65 . . .	11·17	11·19	10·82	10·79	11·51	11·55
75 . . .	6·72	6·81	6·49	6·52	6·93	7·04
85 and upwards .	3·87	4·00	3·73	3·78	3·98	4·15

From this table it will be seen that the expectation of life has been increased at all groups of ages up to twenty-five among males, and up to fifty-five among females. But Mr. Humphreys, by a further analysis of the more extended life-tables, also shows that as much as 66 per cent of the increased duration of human life in England is lived at what is called the useful and productive period, namely, between 20 and 60 years, and not more than 34 per cent at the dependent periods either of childhood (0-20), or of old age (60 and upwards). These figures are very reassuring, and sufficiently refute the pessimist assertions which have recently been advanced with reference to the reduced death-rate, that sanitary improvements have only resulted in an increase in the passive endurance of life rather than in an increase of true vitality and genuine usefulness.

It may here be noted that a new life-table, based upon the mortality in 1871-80, has been constructed by Dr. Ogle, the accomplished successor of Dr. Farr; and though the new tables do not strictly correspond owing to the different periods in which the calculations are based, the conclusions at which Mr. Humphreys arrived are strictly corroborated by Dr. Ogle. (See Supplement to Forty-fifth Annual Report of the Registrar-General.)

5. *Morbidity.*—This term has recently been introduced to denote the amount of illness existing in a given community, and is intended to express the sick-rate just as the term mortality expresses the death-rate.

In the absence of any complete system of registration of cases of disease, and taking into consideration the fact that disease often sets in so insidiously and is frequently so ill-defined, it becomes a matter of considerable difficulty to estimate the amount of sickness which may be prevalent in any district during any stated period. Hitherto such estimates have been based mainly on the records of

sick-clubs, benefit societies, army, navy, and police, and they apply solely to disabling sickness occurring amongst lives which may be regarded as selected. From such records of sick-time, Dr. Farr, in his Supplement to the Thirty-fifth Report of the Registrar-General, has estimated that to one annual death in a body of men two men are on an average constantly suffering from sickness of some severity, or in other words, that to every death there are two years of severe sickness. In the police and some friendly societies, the constantly sick to every death that occurs are 2·8, while in the army at home the ratio is 4·2, the difference being due to the prevalence of enthetic disease.

With regard to diseases which, as a rule, occur only once during a lifetime, such as scarlatina, smallpox, and some of the other zymotic diseases, an approximate estimate of the number of cases occurring in a district can sometimes be made from the number of deaths. Thus the mortality occurring among cases of scarlatina admitted into hospitals has been taken as a basis for calculating the number of cases in any district from the deaths registered in such district, and the ratio estimated in this way has been given as about ten cases for every death. But such estimates are comparatively valueless, because, apart from the incompleteness of the data on which they are based, the mortality will vary very much according to the severity of the epidemic. Far more reliable statistics will doubtless be obtained after an extended experience of the registration of cases of infectious disease in those towns in which powers for compulsory notification have been obtained.

Concluding Remarks.—In drawing conclusions from statistical data, it need hardly be said that great care must be taken to guard against fallacies. For example, the death-rate of a district may be comparatively low by

reason of the preponderance of adult or selected lives, while the sanitary conditions are by no means satisfactory; or again, the total death-rate may not be above the average, while the death-rate in certain portions of the district may be excessively high. Generally speaking, the effects of sanitary improvements and precautionary measures are best indicated by a lowered death-rate from infectious diseases, fever, diarrhœa, and phthisis, and amongst children under five years from all causes. Indeed, it may be said that the death-rate of children under five years of age is in many localities a far more reliable criterion of the sanitary conditions affecting the health of communities than the total annual death-rate, even although every allowance is made for neglect, deficiency of food, mal-nutrition, and exposure. Nor, again, in drawing inferences from mortality returns, must the influence of social causes of disease be forgotten, for the effects of intemperance, immorality, and early or injudicious marriages, especially amongst the lower classes in all our large towns, can scarcely be over-estimated.

CHAPTER XVII.

THE DUTIES OF MEDICAL OFFICERS OF HEALTH

By clauses 189 and 190 of the Public Health Act, 1875, it is enacted that it shall be the duty of every urban and of every rural sanitary authority, throughout England and Wales, to appoint from time to time a legally-qualified medical officer or officers of health for the efficient execution of the purposes of the Sanitary Acts. In the case of rural sanitary districts, such officers may be the district medical officers of unions, who are to a certain extent under the control of the Local Government Board; but in the case of urban sanitary districts, those medical officers of health are alone subject to the control of the Local Government Board whose salaries are partly paid out of monies voted by Parliament. Such sanitary authorities, therefore, who do not choose to receive assistance from the public purse in the payment of their health-officers, may appoint or dismiss such officers without the consent of the Local Government Board, and may issue such regulations for their guidance as they may from time to time determine. In either case, however, the duties of the medical officer of health will, in great measure, be identical as regards the main points; and hence the following regulations, which have been issued by the Local Government Board for the guidance of medical officers of health whose appointments are made subject to the approval of the Board, may be considered

as more or less applicable to all health officers. By an order, dated 11th November 1872, which is still in force, these duties are thus defined :—

"The following shall be the duties of the medical officer of health in respect of the district for which he is appointed ; or, if he shall be appointed for more than one district, then in respect of each of such districts :—

"1. He shall inform himself, as far as practicable, respecting all influences affecting or threatening to affect injuriously the public health within the district.

"2. He shall inquire into and ascertain by such means as are at his disposal the causes, origin, and distribution of diseases within the district, and ascertain to what extent the same have depended on conditions capable of removal or mitigation.

"3. He shall, by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed of the conditions injurious to health existing therein.

"4. He shall be prepared to advise the sanitary authority on all matters affecting the health of the district, and on all sanitary points involved in the action of the sanitary authority or authorities ; and in cases requiring it, he shall certify, for the guidance of the sanitary authority or of the justices, as to any matter in respect of which the certificate of a medical officer of health or a medical practitioner is required as the basis or in aid of sanitary action.

"5. He shall advise the sanitary authority on any question relating to health involved in the framing and subsequent working of such bye-laws and regulations as they may have power to make.

"6. On receiving information of the outbreak of any contagious, infectious, or epidemic disease of a dangerous character within the district, he shall visit the spot without delay and inquire into the causes and circumstances of such outbreak, and advise the persons competent to act as to the measures which may appear to him to be required to prevent the extension of the disease, and, so far as he may be lawfully authorised, assist in the execution of the same.

"7. On receiving information from the inspector of nuisances, that his intervention is required in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall, as early as practicable, take such steps authorised by the statutes in that behalf as the circumstances of the case may justify and require.

"8. In any case in which it may appear to him to be necessary

or advisable, or in which he shall be so directed by the sanitary authority, he shall himself inspect and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, or flour, exposed for sale, or deposited for the purpose of sale, or of preparation for sale, and intended for the food of man, which is deemed to be diseased, or unsound, or unwholesome, or unfit for the food of man; and if he find that such animal or article is diseased, or unsound, or unwholesome, or unfit for the food of man, he shall give such directions as may be necessary for causing the same to be seized, taken, and carried away in order to be dealt with by a justice according to the provisions of the statutes applicable to the case.

"9. He shall perform all the duties imposed upon him by any bye-laws and regulations of the sanitary authority duly confirmed, in respect of any matter affecting the public health, and touching which they are authorised to frame bye-laws and regulations.

"10. He shall inquire into any offensive process of trade carried on within the district, and report on the appropriate means for the prevention of any nuisance or injury to health therefrom.

"11. He shall attend at the office of the sanitary authority or at some other appointed place, at such stated times as they may direct.

"12. He shall from time to time report, in writing, to the sanitary authority, his proceedings and the measures which may require to be adopted for the improvement or protection of the public health in the district. He shall in like manner report with respect to the sickness and mortality within the district, so far as he has been enabled to ascertain the same.

"13. He shall keep a book or books, to be provided by the sanitary authority, in which he shall make an entry of his visits, and notes of his observations, and instructions thereon, and also the date and nature of applications made to him, the date and result of the action taken thereon, and of any action taken on previous reports, and shall produce such book or books, whenever required, to the sanitary authority.

"14. He shall also prepare an annual report to be made at the end of December in each year, comprising tabular statements of the sickness and mortality within the district, classified according to diseases, ages, and localities, and a summary of the action taken during the year for the preventing the spread of disease. The report shall also contain an account of the proceedings in which he has taken part or advised under the Sanitary Acts, so far as such proceedings relate to conditions dangerous or injurious to health, and also on account of the supervision exercised by him, or on his

advice, for sanitary purposes, over places and houses that the sanitary authority has power to regulate, with the nature and results of any proceedings which may have been so required and taken in respect of the same during the year. It shall also record the action taken by him, or on his advice, during the year, in regard to offensive trades, bakehouses, and workshops.

"15. He shall give immediate information to the Local Government Board of any outbreak of dangerous epidemic disease within the district, and shall transmit to the Board, on forms to be provided by them, a quarterly return of the sickness and deaths within the district, and also a copy of each annual and of any special report.

"16. In matters not specifically provided for in this order, he shall observe and execute the instructions of the Local Government Board on the duties of Medical Officers of health, and all the lawful orders and directions of the sanitary authority applicable to his office.

"17. Whenever the Diseases Prevention Act of 1855 is in force within the district, he shall observe the directions and regulations issued under that Act by the Local Government Board, so far as the same relate to or concern his office."

For the efficient and conscientious discharge of these duties, it is evident that a medical officer of health must make himself thoroughly acquainted with the fundamental principles of public and practical hygiene, with the general and local circumstances which may affect the health of the population in his district, and with the various clauses of the Public Health and other Acts which more immediately concern his office. So much is left to his discretionary power in advising the sanitary authority, and in certifying as to what is or is not injurious to the public health, that he cannot but feel the grave responsibility which will devolve upon him, if through ignorance or neglect on the one hand, or through mistaken zeal and want of tact on the other, he fails to carry out his duties honestly, judiciously, and efficiently.

As there is no doubt that considerable difficulty will be experienced at the outset by most health officers in regard to the mode in which their duties should be carried out, the various suggestions and practical details summar-

ised under the following sections, may, it is hoped, prove as serviceable as they are reliable :—

Section I.—Natural Conditions affecting the Health of the Population contained in the District.

These comprise the geological and topographical characteristics of the district, the water-supply, and the climate.

1. *Geological Conditions.*—Official information as regards these may be obtained from the Ordnance maps and the special sections published by the Surveyor-General; while fuller details could be readily collected from local sources. In most districts there will generally be found some one who has made the geology of the locality a special study.

2. *Topographical Conditions.*—These relate to the situation of the various parts of the town or district, whether low-lying, elevated, or sloping.

3. *Water-Supply.*—The quantity and quality of the obtainable water-supply in a district will depend very much on the two previous sets of conditions. So also will the nature of the subsoil and the facilities for drainage and sewerage. All this, however, has been fully explained in previous parts of this work.—(See Chapters VI., VIII., and XIII.)

4. *Climate.*—Under this heading are comprised the meteorological conditions of the district, such as the daily temperature, and rainfall, the force and direction of winds, the barometric pressure, the degree of humidity, and the amount of ozone. In most large towns these observations are already being carefully recorded, and where this is the case, the health officer should endeavour to obtain, through the sanitary authority, the record of the observations

weekly. In districts where no such observations are made, it will be no part of his duty to supply this information, but at the same time it is necessary that he should take cognisance of meteorological fluctuations, because they constitute very important factors of health or disease in every district.

SECTION II.—ARTIFICIAL CONDITIONS AFFECTING THE HEALTH OF THE POPULATION CONTAINED IN THE DISTRICT; such as—

1. *Habitations of the People.*—So far as possible the sanitary condition of every house in the district should be inquired into. Of course the health officer himself could not undertake such a laborious inquiry, but in towns it could be easily and efficiently carried out by the temporary appointment of one or more competent persons, who would be paid by the sanitary authority and directed by the health officer; while in small urban or rural districts it can be carried out by the sanitary inspector.

In carrying out a systematic inquiry of this description in rural districts, it is advisable that the inspector should complete the survey of one or more parishes or villages before submitting the details to the medical officer of health, who would then appoint a day for going over the survey with the inspector. During the inspection he should satisfy himself as to the accuracy of the returns, advise with regard to particular defects, and in this way make himself fully acquainted with the sanitary condition of every part of his district in detail. The tabulated forms to be used for such a survey, when it is authorised by the sanitary authority, will vary slightly, according as the district is urban or rural. Those devised by Dr. Bond of Gloucester, although somewhat bulky, will be found to be well arranged and admirably suited for rural districts.

They contain the following headings in the several columns :—Number ; No. of case in nuisance book ; date of inspection ; situation and description of premises ; names of occupier and owner ; number of living-rooms, sleeping-rooms, and inmates ; nature, situation, and condition of closet-accommodation ; nature of water-supply ; defects in drainage, ventilation, or general condition of premises ; existence of any special source of actual or possible nuisance ; remarks by medical officer of health ; additional observations. With very rare exceptions, the inspector will meet with no opposition in carrying out the survey, nor the medical officer of health in obtaining any information with regard to any points which he may consider desirable. Further particulars with regard to the sanitary condition of premises, overcrowding, nuisances generally, and how to draw up reports, will be given in Section IV. (See also Chapter IX.)

2. *Water-Supply.*—In districts where the water-supply is public the medical officer of health should make himself acquainted with the quality of the water, amount per head, and the risks of pollution, both as regards the source of supply and the mode of distribution. The nature of the supply, whether constant or intermittent ; the relation between mains and closets ; the situation and condition of cisterns ; the separation of cisterns for domestic supply from those supplying closets ; the situation of overflow pipes, and the like, are all points which should receive careful attention. In rural districts the sufficiency of the water-supply, as well as its quality, the situation of wells, and the risks of pollution, should all be duly noted, and samples of suspicious well-water should be examined. In villages where the water-supply is insufficient it will become a question for the medical officer of health to advise generally as to how this want may best be remedied, whether by providing one or more public

wells, by introducing a public supply, by compelling neighbouring owners of property to unite in providing a sufficient supply under the new Public Health (Water) Act, by storage of the rainfall, or by carting water into the village to meet special emergencies, leaving of course all practical details to be dealt with by the sanitary engineer or inspector. (Chapters VI. and VII.)

3. *Drainage, Sewerage, Scavenging, etc.*—In towns full information with regard to these conditions will be obtained from the borough engineer or town surveyor. Special attention should be given to the ventilation and flushing of sewers, and the condition of house-drains as regards ventilation, flushing, freedom from smell, and construction; while the ventilation of water-closets, soil-pipes, and, as far as possible, the severance of all direct communication of house-drains with sewers, are additional points of importance which should not escape notice. The efficiency of the scavenging arrangements should also be carefully inquired into. In country districts it will devolve upon the medical officer of health to report as to whether the drainage of particular villages is satisfactory, and to recommend or not, as he may think fit, as to whether a competent engineer should be called in to survey and prepare plans. In certain cases, too, he will have to inquire and decide as to whether public scavenging has not become necessary to ensure adequate local cleanliness. (See Chapters XI., XII., and XIII.)

4. *Factories, Workshops, Bakehouses, Public Institutions, Slaughter-houses, etc.*—These should be examined with reference to overcrowding, air-impurities, and the production of nuisances generally. (See Chapter III. and Section IV. of the present chapter.) Factories already under Government inspection would not of course be subject to the supervision of the health officer, except in so far as they prove to be a nuisance or injurious to the

health of the neighbouring inhabitants. In country districts special attention should be given to the sanitary condition of village schools, whether public or private, and also to the sanitary condition of graveyards.

Section III.—Vital Statistics.

In addition to obtaining a full knowledge of the natural and artificial conditions which affect the health of the population, the medical officer of health should also make himself acquainted with the vital statistics of his district. By referring to the more recent Quarterly and Annual Reports of the Registrar-General, the books of the district-registrars, the abstracts of the Boards of Guardians, and any reports which have already appeared with regard to the health of the district, he will obtain all the statistical data representing its vital history for the past few years, as indicated by the number of the population, its rate of increase, the birth-rate, the marriage-rate, the rate of mortality, the prevalency of epidemic or other specially fatal diseases, the death-rate at different ages, the amount of pauperism, etc. From the last census returns, again, he will obtain much useful information as regards the areas, houses, and population, and the ages, civil condition, and occupation of the people.

Amongst other works which will be found very serviceable are the Supplement to the Thirty-fifth Annual Report of the Registrar-General, published in 1875, and the Supplement to the Forty-fifth Annual Report, published in 1885. Both supplements are full of information of the most varied kind, and exhibit in the most masterly way the wide range of logical deductions that can be based on vital statistics when properly tabulated and accurately arranged.

Such a retrospect, it need hardly be said, would form

a sound basis of local statistical knowledge to start with, and by pursuing the same course with regard to the registration and pauper returns, which should be obtained regularly, the medical officer of health will be in a position at all times to inform the sanitary authority concerning the prevalence of infectious and preventable diseases, and advise as to what steps should be taken. But as the death-rate gives no sufficient indication of the sick-rate, he should also obtain the pauper sick returns immediately after each meeting of the guardians, and as far as possible the returns from the public medical institutions in his district. Arrangements should likewise be made through the sanitary authority, that poor-law medical officers should report without delay the occurrence of any case of fever or infectious disease, and that the district-registrar should at once forward a return of any death from such disease. Further, if the medical officer of health is precluded from practice, he will generally find that the medical practitioners in his district will give him much timely information, provided he is careful not to make himself too officious; but until the registration of cases of infectious disease is rendered compulsory, the only returns which are provided for in the instructions of the Local Government Board are the returns of the district-registrar, the pauper sick returns, and such returns with regard to infectious disease as the sanitary inspector can obtain. Arrangements may, however, be made with local practitioners to report all cases of certain specified dangerous infectious diseases on payment of a fixed fee per case by the sanitary authority.

The district-registrars throughout the country are instructed by the Registrar-General to forward the returns of births and deaths to the medical officer of health, and are allowed 2d. per entry for remuneration, which the sanitary authority is empowered by the Local Government

to pay. The sanitary authority also supplies the blank forms, and defrays the expense of postage. Except as regards deaths from fever or other infectious disease, a return of which should be forwarded immediately, the usual returns of the registrar should be forwarded to the medical officer of health at the close of every week. Blank forms may be obtained from Messrs. Knight and Co., publishers, Fleet Street, London ; Messrs. Shaw and Sons, Fetter Lane, London ; or Messrs. Farrant and Frost, Merthyr-Tydfil. (See Appendix.)

By means of the information supplied by these weekly returns, the medical officer of health is enabled to tabulate the mortality statistics in such a manner as will show the birth-rate, the total death-rate, the death-rate at different ages, the death-rate from zymotic disease, the connection between the total infantile or zymotic death-rate, and the sanitary or insanitary condition of various parts of his district, the prevalency of any particular diseases in certain areas, and so on. If the district is a large urban one, the diseases may be classified according to sub-districts or streets ; and if it be a large rural one, they may be classified according to sub-districts or parishes. In large urban districts the classification should be that used by the Registrar-General, but in small urban or rural districts it is by no means necessary to compile elaborate tables, and the classification which is given in the official returns to the Local Government Board, or some similar classification, will answer all practical purposes. For the sake of comparison it is much to be regretted that some uniform system of classification is not enforced in all districts, a simple system for rural and small urban districts, and a more elaborate system for urban districts containing say 25,000 inhabitants and upwards. In combined districts, too, there is some chance of confusion arising from the fact that the registration sub-districts

are frequently not conterminous with the several sanitary districts, inasmuch as small urban districts generally form part of a registration sub-district, the other part being included in a neighbouring rural sanitary district.

What is required of the medical officer of health is that he should classify his returns honestly and with no preconceived ideas as to what the figures are to prove; and although mistakes may sometimes be made in diagnosis, he is bound to classify the returns as he receives them, unless after due inquiry he is convinced that in exceptional cases such mistakes have been made. Even then it is essential, as a statist, that he should present the returns as they are sent in to him; and if he has reason to question their accuracy, he should honestly state his reasons, after as far as possible consulting with the medical attendant. This of course is always a delicate matter, requiring the utmost tact and conscientiousness, because under any circumstances it is an interference liable to be resented, and especially if the medical officer of health is now precluded from practice. But, whether the medical officer of health is in practice or not, enough has been said in the preceding chapter to show not only the necessity of constant and systematic attention on his part to the vital statistics of his district, but also the immense assistance which a logical use of them will afford him in estimating rightly the separate or combined influences of avoidable or removable causes of disease. (See Chapter XVI.)

Section IV.—Duties required of the Medical Officer of Health for the efficient Execution of the Sanitary Acts.

As the health officer must "be prepared to advise the sanitary authority on all points involved in the

action of the sanitary authority or authorities," it is necessary that he should make himself acquainted with the Public Health Act of 1875, and the other Acts or portions of them which more immediately concern his office. Previous to the consolidation of the various Sanitary Acts in the Public Health Act of 1875, the task of wading through these numerous enactments, so as to obtain a practical knowledge of the clauses affecting the duties of the health officer, was by no means an easy one. All this, however, is now very much simplified, and the only Acts which the health officer need consult may be confined, with a few exceptions, to the Public Health Act, 1875, the Artisans' Dwellings Act, 1875, the Canal Boats Act, 1877, and the Public Health (Water) Act, 1878. And here it may be observed that though the Public Health Act permits the medical officer of health to exercise any of the powers with which an inspector of nuisances is invested, it is not his duty to search for nuisances. By all means let him make an inspection whenever he deems it necessary, or when he has reason to believe that the sanitary inspector is not properly attending to his duty, but he should avoid as far as possible interfering with matters which in the first instance concern the office of the surveyor or sanitary inspector. He should, nevertheless, be fully qualified to advise and give suggestions, and in order to do so it is essential that he should be well acquainted with practical details. The clauses in the Public Health Act, to which special attention should be directed, are classed in order as they appear in the list, under the following headings :—

1. *Sewerage and Drainage* (clauses 13-26).—The two most important clauses in this section, so far as the medical officer of health is concerned, are clause 19, which makes it incumbent on every local authority to have all sewers constructed, ventilated, and kept, so that

they shall not be a nuisance; and clause 23, which empowers local authorities to enforce the drainage of undrained houses, such drainage to be carried out in all particulars to the satisfaction of the surveyor. (See Chapter XI.)

2. *Privies, Water-closets, etc.* (clauses 35-41).—These clauses give full powers to sanitary authorities to enforce closet accommodation, and to provide that all drains, water-closets, earth-closets, privies, ashpits, and cesspools, within their district, be constructed and kept so as not to be a nuisance or injurious to health. With regard to structural details, and especially the alterations which are required to remedy the defects which are so commonly connected with the closet accommodation of rural districts, see Chapter XI.

3. *Scavenging and Cleansing* (clauses 42-47).—By virtue of these clauses, sanitary authorities are empowered, or they may be required by order of the Local Government Board, to provide for the cleansing of streets and the removal of refuse; and in localities where the scavenging is undertaken by the sanitary authority, any occupier of premises may claim a penalty not exceeding five shillings a day from the local authority if they neglect, after due notice, to cleanse any earth-closet, privy, ashpit, or cesspool, belonging to such premises. In all cases, therefore, where the medical officer of health is convinced that public scavenging has become necessary, he ought to urge that this duty be undertaken by the sanitary authority, and if they refuse to comply with his request, he should have no hesitation in appealing to the Local Government Board to issue the necessary order. In places where there is no public scavenging, the local authority may make bye-laws imposing the duty of cleansing footways and pavements adjoining premises, and of removing all offensive refuse from the premises, on the occupier.

Clause 46 gives power to order the cleansing and purifying of houses on the certificate of the medical officer of health; and clause 47 imposes penalties in respect to certain nuisances occurring on premises in urban districts. (See Chapter XI.)

4. *Offensive Ditches and Collections of Matter* (clauses 48-50).—These clauses provide for the obtaining of orders for cleansing offensive ditches lying near to or forming the boundaries of districts; for the removal of filth-accumulations on the certificate of the sanitary inspector; and for the periodical removal of manure from mews and other premises in urban districts.

5. *Water-supply* (clauses 51-70).—These clauses relate to the general powers of sanitary authorities for supplying their districts with water, whether by waterworks or wells; to provisions for the protection of water-supplies against pollution; and to the closing, cleansing, or repairing of polluted wells. (See Chapters VI. and VII.)

In the Public Health (Water) Act, 1878, power is given to enforce a wholesome supply for isolated houses or groups of houses if within a certain limit of outlay; and it is further enacted that no house which has been newly built or rebuilt shall be occupied unless such wholesome supply is first provided. The Act applies specially to rural districts, and if systematically carried out will be of immense service in improving the health of these districts.

6. *Regulation of Cellar Dwellings and Lodging-Houses* (clauses 71-90).—Besides prohibiting the occupation of cellars absolutely, or only under certain conditions, these clauses provide for the registration of common lodging-houses, and the issuing of bye-laws for their regulation, and they also empower the Local Government Board to authorise the local authority to make bye-laws in respect to houses other than common lodging-houses which are let in lodgings, or occupied by members of more than one

family. As regards watering-places, and other fashionable health resorts, this last provision is one of great importance, inasmuch as it would not only ensure the removal of any sanitary defects from houses let in lodgings, but it also renders it compulsory on lodging-house keepers to give immediate notice to the sanitary authority in cases of infectious disease, and to take proper precautions.

7. *Nuisances* (clauses 91-111).—As this section of the Public Health Act is a very important one, it may be considered more fully in detail. The several classes of nuisances are defined by the Act as follows :—

(1.) "Any premises in such a state as to be a nuisance or injurious to health."

It need hardly be said that this definition, by reason of its vagueness, includes a great variety of sanitary defects, and, like the other definitions, implies injury to health, whether probable or actual, as a consequence of the nuisance. Unfortunately, too, this vagueness is, if possible, still further increased by the definition in the preamble of the Act, which states that "*lands* and *premises* include messuages, buildings, lands, easements, and hereditaments, of any tenure." All this gives ample room for legal quibbles, but, so far as the duties of the medical officer of health and the sanitary inspector are concerned, there is usually little difficulty experienced in carrying out the intention of the Act. The sanitary defects implied in the definition have reference, for the most part, to the cleansing or whitewashing of dirty houses ; the repair of roofs that let in the rain ; the repair of walls and uneven floors ; the opening of fastened windows to improve the ventilation ; the repair of closets ; the relaying of defective drains ; the ventilation, trapping, or disconnection of house-drains ; the removal of privies or pig-styes abutting against outside walls ; the prevention of dampness as far as possible ; the repair of yards, and,

especially in rural districts, the sanitary improvement of farm-yards adjoining the dwelling-houses. When it is not possible to put a house into habitable repair, or when the necessary repairs are not carried out in compliance with the notice issued by the sanitary inspector, power is given, by clause 97, to close the house by order of a Justice. With regard to the difficulties of dealing with the question of defective house-accommodation, see Chapter IX.

(2.) "Any pool, ditch, gutter, water-course, privy, urinal, cesspool, drain, or ashpit, so foul, or in such a state as to be a nuisance, or injurious to health."

This definition requires no further comment than this, that whenever any offensive smell is given off by any pool, ditch, etc., whether it be in the proximity of dwellings, or near any frequented road or footpath, there is sufficient evidence of the existence of a nuisance which calls for removal. All foul privies, cesspools, and drains in rural districts can be dealt with under this clause.

(3.) "Any animal so kept as to be a nuisance or injurious to health."

This definition applies to pig-styes, fowl-pens, dog-kennels, cow-byres, etc. In dealing with nuisances of this description, it often happens that the abatement may be effected in various ways. For example, a nuisance arising from a pig-stye may be abated sometimes by keeping the animal in a more cleanly way, by lessening the number of pigs, by properly draining the pig-stye, by removing the pig-stye if it be too near a dwelling or too near a frequented path, or by prohibiting the keeping of pigs altogether. It may safely be laid down as a rule, that pig-styes close to dwellings, or under bedroom windows, will always be more or less a nuisance, no matter how carefully the animal may be kept.

(4.) "Any accumulation or deposit which is a nuisance or injurious to health."

In this definition are included offensive manure-heaps, or other filth-accumulations, which are close to dwellings or frequented paths. It also applies to offensive refuse-heaps of every description, — the only exception being made "in respect of any accumulation or deposit necessary for the effectual carrying on any business or manufacture, if it be proved to the satisfaction of the Court that the accumulation or deposit has not been kept longer than is necessary for the purposes of the business or manufacture, and that the best available means have been taken for preventing injury thereby to the public health."

(5.) "Any house or part of a house so overcrowded as to be dangerous or injurious to the health of the inmates, whether or not members of the same family."

In previous parts of this work the necessity for an ample amount of cubic space for the requirements of perfect health has been strongly insisted on — an amount, however, which it is impossible to obtain or enforce in the dwellings of the poorer classes and in common lodging-houses. Practically it is found that 300 cubic feet per head is the highest *minimum* which can be enforced in most large towns, and even that amount cannot be exacted in the case of many families consisting of husband and wife and young children. In rural districts also the difficulty of dealing with this form of nuisance on reasonable and equitable grounds is quite as great as it is in towns, if not greater; and as an instance in point, I may quote the following remarks from one of my reports for 1874:—"In places where there is a scarcity of houses, it is evidently impossible to abate the nuisance to any extent, because in attempting to reduce the overcrowding in one part you only increase it elsewhere. But in Mid-Warwickshire this difficulty has not arisen, partly because

the district is mainly agricultural and can only maintain a limited number of the labouring class, and partly, too, I have no doubt, because during the last two or three years there has been a considerable exodus from a good many of the villages in consequence of the agricultural labourers' movement. The cases of overcrowding met with have been generally confined to single families occupying houses with only one sleeping-room, and in endeavouring to deal with this form of nuisance there were several points which had to be considered. In the first place, it was clear that if the minimum allowance of cubical space per head was made too high, the instances of overcrowding, judged by this standard, would have become so numerous that any attempt to deal with them would have been impossible; in the second place, the ages of the children had to be taken into account; and in the third place, it became a question whether, in condemning a house as being too small for the family, another and suitable one was to be found in the village. With regard to cubical space, it appeared to me, after careful inquiry into the average amount of sleeping accommodation, that the standard of 200 cubic feet per head was as high as it could be raised for families consisting of parents and young children, though at the same time I am free to confess that a minimum of 300 cubic feet space, even with good means of ventilation, is little enough for the requirements of health. But in cases where it was found that grown-up children of both sexes slept in the same room, or in the same room with their parents, the question of cubic space became a matter of secondary consideration, and the plea of overcrowding has been insisted on in the interests of decency as much as on the score of health. It will thus be seen that the cases of overcrowding met with had to be decided according to the special circumstances of each rather than in accordance with any

fixed rules, and though the minimum cubic space which has been adopted is small, it must be borne in mind that the dilapidated state of most of the cottages permits a freer interchange of air than is usually to be obtained in newer and better built houses. All this is, of course, an admission that only the more glaring cases of overcrowding have been dealt with; but with so many cottages containing only one sleeping-room, and taking into consideration the size of the rooms, it is impossible to lessen the extent of the evil except by acting on principles such as these. As it is, many cases of overcrowding have been abated, and the notices issued by the inspectors have been so generally complied with that only a few cases had to be brought before the magistrates." Grown-up sons or daughters should be regarded as lodgers in all cases of overcrowding, and their removal insisted on if the family cannot procure a larger house.

To sum up: The word "nuisances" includes "any premises in such a state as to be a nuisance or injurious to health: any . . . privy, cesspool, drain, or ashpit, so foul or in such a state as to be a nuisance or injurious to health: any accumulation or deposit which is a nuisance or injurious to health: and any house or part of a house so overcrowded as to be dangerous or injurious to the health of the inmates, whether or not members of one family."

If after notice a nuisance is not abated, or if after notice it is abated, but is, in the opinion of the authority, likely to recur on the same premises, it is their duty to institute proceedings before justices. The justices are empowered by their order to require the person on whom the order is made "to comply with all or any of the requisitions of the notice or otherwise to abate the nuisance within a time specified in the order, and to do any works necessary for that purpose." Further, they may make an order prohibiting the recurrence of the

nuisance, and directing the execution of any works necessary "to prevent the recurrence;" or they may make an "order both requiring abatement and prohibiting recurrence of the nuisance." By the order the justices may impose a penalty not exceeding £5 on the person on whom the order is made.

If in the judgment of the justices the nuisance is such as to render the house unfit for human habitation, they may prohibit its being used for that purpose until it is rendered fit for habitation, and in that case the house may not be let or inhabited until by a further order the justices have declared that it is habitable. A person not obeying an order for abatement, if he fails to satisfy the justices that he has used all due diligence to carry out the order, is liable for every such offence to a penalty not exceeding 10s. per day during the default, and a person knowingly or wilfully acting contrary to an order of prohibition, is liable to a penalty not exceeding 20s. per day during such contrary action. Further, in the case of such default the authority may enter the premises to which the order relates, and abate the nuisance, and do whatever may be necessary in execution of the order, and charge the cost to the person on whom the order is made.

It is also to be observed that when two convictions in respect of the overcrowding of the same premises have taken place within a period of three months, whether the persons convicted were or were not the same, the justices may order the closing of the house for such time as they may deem necessary.

(6.) "Any factory, workshop, or workplace (not already under the operation of any general Act for the regulation of factories or bakehouses), not kept in a cleanly state, or not ventilated in such a manner as to render harmless, as far as practicable, any gases, vapours, dust, or other impurities generated in the course of the

work carried on therein, that are a nuisance or injurious to health, or so overcrowded while work is carried on as to be dangerous or injurious to the health of those employed therein." (See Chapter III.)

(7.) "Any fireplace or furnace which does not, so far as practicable, consume the smoke arising from the combustible consumed therein, and which is used for working engines by steam, or in any mill, factory, dyehouse, brewery, bakehouse, or gaswork, or in any manufacturing or trade process whatsoever; and any chimney (not being the chimney of a private dwelling-house) sending forth black smoke in such quantity as to be a nuisance, shall be deemed to be nuisances liable to be dealt with summarily in manner provided by this Act;" provided always that it can be shown that the best practical means have been adopted to consume the smoke, having regard to the manufacture or trade, and that due care has been exercised by the person in charge of the same.

In order to obviate nuisances of this description, all furnaces or factory fireplaces should have chimneys of sufficient height, and should be provided with a smoke-consuming apparatus. Very often it is found that nuisance arises from neglect in stoking.

8. *Offensive Trades* (clauses 112-115).—By these clauses power is given to urban sanitary authorities to restrict the establishment of offensive trades in their districts, such as bone-boiling, soap-boiling, tallow-melting, etc.; to make by-laws with respect to the same; and to direct complaint to be made before a justice, if the effluvia given off are certified to be a nuisance or injurious to health, by the medical officer of health, or by two legally-qualified practitioners, or by any ten inhabitants of the district. Before a conviction can be obtained in respect to established trades, it will be necessary to prove to the satisfaction of the Court that the best practical means for

the abatement of the nuisance have not been adopted; and as the medical officer of health is liable, in most cases, to be called upon to give skilled evidence, it is necessary that he should be well acquainted with the process of manufacture, or the details of the trade complained of, the nature of the effluvia given off, and the best means which should be adopted to prevent nuisance. Such knowledge can, of course, only be obtained by inspecting offensive trades, and it must necessarily be supplemented by a thorough acquaintance with practical chemistry. Unless the medical officer of health is an expert in these matters, the best course to pursue is to recommend the manufacturer or tradesman, against whom complaint is made, to call in some competent person to advise him as to what steps he should take to prevent nuisance; and in the event of no steps being taken, he should recommend the sanitary authority to consult an expert, who would give evidence before the magistrates if necessary.

With proper precautions, the manufacturer of offensive products may, in the greater majority of instances, carry on his trade without causing serious nuisance to the neighbourhood, and not unfrequently finds it advantageous even as regards pecuniary interests when he is compelled to utilise his waste offensive refuse. Without entering into details, it may be said generally that all foul matters should be conveyed to the works in properly-constructed vans or tanks, which can be covered with tight-fitting lids, and that they should be stored in closed chambers or tanks, ventilated, if necessary, into the furnace fires, or into special scrubbers. All foul processes, such as oil-boiling, tallow-melting, and the like, should be carried on in boilers with tight-fitting lids; and the effluvia given off should be conducted first to a condenser to get rid of the steam, if necessary, and then to the furnace-fire to be consumed. The sulphuretted hydrogen and ammonium

compounds which are given off in the manufacture of salts of ammonia from gas-liquor should also be conducted from the vats to the furnace-fire to be burnt. Again, all gases and vapours which can be condensed or absorbed should be passed through condensers or absorbents specially suited for them, as, for example, water in the form of spray, or scrubbers charged with water, sulphuric acid, or alkaline solutions.

In Dr. Ballard's valuable report concerning offensive trades, already referred to in Chapter III., he thus classifies the ordinary sources of origin of effluvium nuisances :—

"1. Accumulation of filth on or about the business premises, or on its removal from the premises in an offensive condition.

"2. A generally filthy condition of the interior of the buildings and the premises and utensils generally.

"3. An improper mode of disposing of offensive refuse, liquid or otherwise.

"4. Insufficient and careless arrangements in the reception of offensive materials of the trade, or in the removal of offensive products either from the premises or from one part of the premises to another.

"5. An improper mode of storing offensive material or offensive products within the works.

"6. The escape of offensive gases or vapours given off during some part or parts of the processes to which the materials of the trade are subjected into the atmosphere outside the works."

The report contains abundant illustrations of the modes in which effluvium nuisances may arise from business premises, and is replete with information concerning methods in use, or which may be devised, to obviate or minimise them ; but without referring to particular trades, it will be sufficient to indicate the general principles on which prevention should be based, and these are laid down by Dr. Ballard as follows :—

"As respects the first and second of these sources of effluvium nuisances, the obvious remedy is 'cleanliness' in the broadest sense of the word.

"1. Filth should be removed from the premises speedily in the

impervious covered vessels in which it ought always to be collected from time to time during the day.

"2. Those parts of the interior of premises liable to become dirty or encrusted with filth or decomposable matter, and all the utensils employed, should be regularly cleansed. Such structural and working arrangements should be made as shall not only tend to prevent such defilements, but also tend to facilitate cleansing.

"3. Solid refuse should be separated from liquid refuse as far as practicable, and each should be disposed of in its appropriate manner, the solids being deposited and speedily removed in covered impervious vessels, and the liquids being run off into proper drains in such a condition as not necessarily to give rise to offensive emanations. Deodorants may sometimes be used with advantage.

"4. Offensive matters necessary for use in the business should be brought upon the premises either in covered impervious vessels, or covered up in such a manner that they shall not be a source of effluvium-nuisance in transit. They should be so received in an enclosed building, and unloaded with due precaution against the issue of effluvia in the process. Offensive products should be removed similarly from the premises. Precautions should also be used in the removal of offensive products from one part of the premises to another. Difficulties in this respect now and then arise in works from insufficient space, or bad arrangements of workshops and receptacles. In such cases as these, modifications may be necessary in the works themselves.

"5. Offensive materials and products of the business should either be stored in impervious vessels or in a close chamber, ventilated, if necessary, in such manner that the effluvia shall not become a nuisance.

"6. Sometimes a careful selection of the materials of the manufacture, or some little modification of the manner of conducting a part of the process, may be sufficient to obviate an effluvium nuisance wholly or partially. But when the evolution of offensive gases or vapours is not thus avoidable, they must be intercepted in their passage to the external air, and dealt with in such a manner as to destroy their offensive character. One method of interception consists in arrangements for drawing off in a continuous manner the air of the entire chamber or workshop in which the offensive effluvia are evolved; but mostly the interception is practicable without doing this. When drawn off or collected, they may, according to their nature, be dealt with in one of five ways:—(1.) They may be discharged into the atmosphere at such an elevation as that they shall be so diluted before reaching the ground as not to be offensive. When this will

not suffice, other means must be used. (2.) If the evolved matters be condensible by cold, they may be passed through an appropriate condensing apparatus. (3.) If soluble in water, they may be submitted to the action of water in an appropriate apparatus, or similarly, to the action of any other liquid better calculated to absorb them. (4.) Sometimes, in like manner, solid substances, with which the effluvia have chemical affinity, may be used with advantage, either in powder or otherwise. (5.) If the evolved matters be combustible, they may be burned by conducting them through a fire." —(*Supplement to Local Government Board Report*, 1876.)

9. *Unsound Meat, etc.* (clauses 116-119).—These clauses empower the medical officer of health or inspector of nuisances to inspect and examine, at all reasonable times, "any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk, exposed for sale, or deposited in any place for the purpose of sale, or of preparation for sale, and intended for the food of man."

In carrying out his duties in this respect, it is advisable that the medical officer of health, when he is not called in by the sanitary inspector, should get that officer, or failing him, a policeman, to seize the condemned articles in order to have them dealt with by a justice. The onus of proving that the article seized was not exposed or deposited for sale, or for preparation for sale, or was not intended for the food of man, rests upon the person charged. Very often, with regard to bad meat, the defence set up is that the article seized was not intended for the food of man, but for feeding dogs, or to be boiled down with other offal as the case may be. So far, however, as the medical officer of health is concerned, he should endeavour, as far as possible, to confine his evidence to the question as to whether the article seized is or is not fit for the food of man, leaving the rest of the evidence to be given by the sanitary inspector or other witnesses. Various practical hints concerning the examination of different articles of food have already been

given in Chapter II., while medical officers of health who are also appointed as public analysts under the "Sale of Food and Drugs Act, 1875," must be specially qualified.

10. *Infectious Diseases, Hospitals, Mortuaries, etc.* (clauses 120-143).—This part of the subject has already been so fully discussed in previous chapters that little more remains to be said. The medical officer of health will have to consider whether, in the event of an outbreak of epidemic disease occurring in his district, there can be procured at short notice sufficient means of isolation. It is true that in some rural districts the population is so very scattered that hospital accommodation is not required, because sufficiently protective measures can be adopted by quarantining, as far as possible, any infected houses, and by supplying properly trained nurses, if they should be wanted, who may be paid either by the sanitary authority, or, in the case of paupers, by the board of guardians. When an outbreak threatens to be serious, a strict watch should be kept on all houses where infectious disease is known to exist, and there should be no hesitation in summoning any one who wilfully or carelessly offends against any of the clauses of the Act. In order that there may be no excuse for pleading ignorance in this respect, the sanitary inspector should be supplied with placards containing the necessary precautions to be taken (see Appendix), a copy of which he should leave at every infected house. In inquiring into the origin of any outbreak, or in giving instructions with regard to preventing its spread, it need hardly be said that the medical officer of health should be very careful not to examine any case without first requesting the sanction of the medical attendant, and unless he has reason to believe that an error has been made in the diagnosis, he should never question the accuracy of any returns which may be made to him. He will also have to consider whether it is necessary that

any schools should be closed, and in recommending that such a step should be taken, he should always give a certificate in the case of public elementary schools, in order that the teacher may not be deprived of the government grant which is allowed on the average attendance of the pupils. According to a recent code issued by the Education Department, it is made incumbent on the managers of all such schools to close them for a stated time by order of the sanitary authority, on receipt of the necessary certificate from the medical officer of health. (See Appendix for Official Memoranda on closing schools.)

With regard to the special provisions of this section of the Act, it may be pointed out that it is imposed as a duty on all sanitary authorities to cause premises to be cleansed or disinfected, and they are further empowered to direct the destruction of any bedding, clothing, or other articles, which cannot otherwise be safely disinfected, and to pay for the same; to supply means of disinfection if necessary; and to provide ambulances, hospitals, and mortuaries. They may either build such hospitals or places of reception, or contract for the use of any such hospital, or part of a hospital, or place of reception; or enter into any agreement with any person having the management of any such hospital; or two or more authorities may combine in providing a common hospital. In populous districts it is always advisable that a proper hospital should be erected; and in small urban and rural districts it will often be found that such hospital accommodation can be most economically and efficiently provided by combination of neighbouring authorities. The term place of reception will include any house which may be rented for the reception of infectious cases, or any hut or tent, or, in the case of seaport towns, any hospital ship.

Clause 132 empowers a sanitary authority to recover the cost of maintenance of any patient who is treated in

any such hospital, who is not a pauper; but inasmuch as the removal of a patient to a hospital may be said to confer as great a benefit on the public as it does on the patient, the enforcement of payment would not only be manifestly unfair in many cases, but would tend greatly to diminish the usefulness of such hospital. According to clause 124 the only persons who can be removed to an infectious hospital by order of a justice, on a certificate signed by a legally qualified practitioner, are the following:—Any person who is suffering from any dangerous infectious disorder, who is without proper lodging or accommodation, or lodged in a room occupied by more than one family, or is on board any ship or vessel; or any person so suffering who is lodged in any common lodging-house. With proper tact, however, on the part of the medical officer of health in enlisting the co-operation of medical attendants, and readiness on the part of the sanitary authority to attend to his recommendations, there will generally be little difficulty experienced in inducing most patients to enter the hospital who are fit to be removed, and whose removal is considered advisable for the public safety.

Although the sanitary protection afforded by hospitals, mortuaries, disinfecting apparatus, and the like, is now placed beyond dispute, it unfortunately happens that sanitary authorities, as a rule, are very slow to exercise the powers vested in them in this respect, unless under the pressure of an epidemic, and consequently the recommendations of the medical officer of health to be prepared beforehand are often thrown aside. But this need not discourage or annoy him in any way. His plain duty is to study carefully the requirements of his district, and having done this to submit his views as clearly and as concisely as he can to the sanitary authority, using the best arguments he can advance to support his case, show-

ing every readiness to answer any questions, and being fully prepared to meet any objections. If his recommendations are not complied with, the onus will rest on the sanitary authority, and not on him; but at the same time he should be careful to bring them forward on some future occasion, when very likely they will either meet with acceptance, or at all events some efforts will probably be made to carry them out.

Clauses 134 to 140 empower the Local Government Board, whenever any formidable outbreak takes place in any part of England, to make regulations for the speedy interment of the dead, for house-to-house visitation, for medical aid and accommodation, and for other means to prevent the spread of disease; but it will only be in cases of the gravest emergency, and when the health of his district is seriously endangered, that the medical officer of health will feel it incumbent on him to recommend the enforcement of these clauses.

In all cases of infectious disease, care should be taken to ensure as far as possible the right use of disinfectants, and it is always a wise economy on the part of sanitary authorities to supply disinfectants gratuitously to those who are too poor to buy them. Moreover, as it is the duty of the sanitary authority to take care that disinfection is efficiently carried out, the sanitary inspector, under the direction of the medical officer of health, should himself superintend or assist in the process of the disinfection of rooms, etc., or in populous districts some one should be specially appointed to act as a disinfector.

For detailed information with regard to hospitals, infectious disease, etc., see Chapters X., XIV., and XV.

11. The other clauses in the Public Health Act which are of special interest to the medical officer of health are the following, and they apply exclusively to urban districts, or districts provided with urban powers:—

Clause 157 gives power to make by-laws respecting new buildings, etc.

Clause 164 empowers an urban sanitary authority to provide places of public recreation.

Clause 166 gives power to provide markets.

Clauses 169-170 give power to provide public slaughter-houses, and to regulate private slaughter-houses.

In Schedule IV. of the Act will be found the various legal forms of notice for requiring the abatement of nuisance, summons, etc., but these concern the clerk and sanitary inspector more than they do the medical officer of health.

12. The other Acts which have not been repealed by the Public Health Act, to which reference may be made, are the Artisans' and Labourers' Dwellings Act, the Bakehouse Regulation Act, and the Baths and Wash-houses Act, but as the essential provisions of these are included in the by-laws of all urban districts in which they are in force, they need not be further considered here.

In towns containing a population of 25,000 and upwards, as enumerated at the last census, an important duty will devolve upon the medical officer of health of recommending the adoption of the Artisans' Dwellings Acts of 1875, when any houses, courts, or alleys, within a certain area of his district, are unfit for habitation by reason of their unhealthiness, and when the sanitary defects in such area cannot be effectually remedied otherwise than by an improvement scheme. As the local authority cannot carry out the intentions of the Act without an official representation made by the medical officer of health, and as he is bound by the Act to make such representation whenever he sees cause for the same, it need hardly be said that the duty imposed upon him will demand the utmost care and conscientiousness on his part.

The Housing of the Working Classes Act, 1885, applies not only to England and Wales, but also to Scotland and Ireland. It extends the powers of the Artisans' Dwellings Acts, 1875, to all urban sanitary districts, and it enables sanitary authorities, rural as well as urban, to obtain, by means of Provisional Orders, compulsory powers of purchasing lands for the purposes of erecting dwellings for the labouring classes where on inquiry it is proved that such accommodation is required, and there is no probability that it will be provided. It also contains provisions for the regulation of tents, vans, sheds, and similar structures used for human habitation; to close, repair, or cleanse them; to deal with cases of overcrowding in them; and to make by-laws for preventing the spread of infectious diseases in them, and generally for the prevention of nuisances connected with them.

The provisions of the Public Health (Water) Act have already been referred to, and the only other Acts with which the medical officer of health should make himself familiar are the Sale of Food and Drugs Act, 1875; the Factory and Workshops Act, 1883, which transfers the supervision of Bakehouses from the Factory Inspectors to sanitary authorities; and the Canal Boats Acts, 1877. This Act empowers the Local Government Board to appoint sanitary authorities having districts abutting on a canal as registration authorities to register boats and number them, and to fix the number, age, and sex of the persons who may be allowed to dwell in each boat. Regulations are also provided for the separation of the sexes, cleanliness, ventilation, habitable condition, and for preventing the spread of infectious diseases. This Act is further amended by the Canal Boats Act, 1884.

13. *By-Laws.*—In all urban districts, the medical officer of health will find that by-laws have already been

framed, and as a matter of course he should at once make himself thoroughly acquainted with their details, and more especially with those which relate to the removal of refuse and the prevention of nuisance, the sanitary arrangements of new buildings, and the inspection and regulation of slaughter-houses, bakehouses, and common lodging-houses. Unfortunately, rural sanitary authorities have no power to issue by-laws with respect to new buildings, etc., unless they are provided with urban powers; but since these can be granted by the Local Government Board, it will become the duty of the medical officer of health to recommend that an application be made for the granting of such powers, whenever he feels assured that the sanitary requirements of his district demand them. In order that he may be fully qualified to advise the sanitary authority with regard to the framing of by-laws when required, the medical officer of health should make himself thoroughly acquainted with the code of model by-laws which have been issued by the Local Government Board.

14. *Legal Proceedings.*— Unless under exceptional circumstances, the medical officer of health should never conduct a case before the justices,—that is the duty of the clerk to the sanitary authority, or in respect to common nuisances, it is often discharged by the sanitary inspector. Although he will often have to recommend that proceedings be taken, his duty, so far as the prosecution is concerned, should be confined to furnishing a certificate or giving evidence when required. With a well-trained inspector, it is seldom that he will be required to give evidence except as regards cases of overcrowding, infected houses, or exposure of infected persons, clothing, etc., unsound meat, nuisances which are likely to be contested, and offensive trades.

15. *Routine of Duty.*— This of course will very much depend on the nature and extent of the district.

It unfortunately happens that in many instances the appointment of medical officer of health is made under circumstances in which he is expected to do but little, and that little only when called upon by the sanitary inspector to certify or give evidence. But in all large urban or combined districts it is necessary that the duties should be carried on as systematically as possible. As already stated, the sanitary inspector or inspectors should be under the supervision of the medical officer of health, and any orders from the sanitary authority affecting the duties of these officials should be conveyed through him or with his concurrence, otherwise he cannot be held responsible for the efficient working of his department. The following are the duties of the sanitary inspector as laid down by an order of the Local Government Board, dated November 11, 1872, and they apply to all inspectors who are appointed subject to the approval of that Board :—

"The following shall be the duties of the inspector of nuisances in respect of the district for which he is appointed, or if he shall be appointed for more than one district, then in respect of each of such districts :—

"(1.) He shall perform, either under the special directions of the sanitary authority, or (so far as authorised by the sanitary authority) under the directions of the medical officer of health, or in cases where no such directions are required, without such directions, all the duties specially imposed upon an inspector of nuisances by the Sanitary Acts, or by the orders of the Local Government Board.

"(2.) He shall attend all meetings of the sanitary authority when so required.

"(3.) He shall, by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed in respect of the nuisances existing therein that require abatement under the Sanitary Acts.

"(4.) On receiving notice of the existence of any nuisance within

the district, or of the breach of any by-laws or regulations made by the sanitary authority for the suppression of nuisances, he shall, as early as practicable, visit the spot, and inquire into such alleged nuisance or breach of by-laws or regulations.

"(5.) He shall report to the sanitary authority any noxious or offensive businesses, trades, or manufactories established within the district, and the breach or non-observance of any by-laws or regulations made in respect of the same.

"(6.) He shall report to the sanitary authority any damage done to any works of water-supply, or other works belonging to them, and also any case of wilful or negligent waste of water supplied by them, or any fouling, by gas, filth, or otherwise, of water used for domestic purposes.

"(7.) He shall from time to time, and forthwith upon complaint, visit and inspect the shops and places kept or used for the sale of butchers' meat, poultry, fish, fruit, vegetables, corn, bread, or flour, or as a slaughter-house, and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, or flour, which may be therein ; and in case any such article appear to him to be intended for the food of man, and to be unfit for such food, he shall cause the same to be seized ; and take such other proceedings as may be necessary in order to have the same dealt with by a justice : Provided that in any case of doubt arising under this clause he shall report the matter to the medical officer of health, with the view of obtaining his advice thereon.

"(8.) He shall, when and as directed by the sanitary authority, procure and submit samples of food or drink, and drugs suspected to be adulterated, to be analysed by the analyst appointed under the Adulteration of Food Act, 1872 ; and upon receiving a certificate stating that the articles of food or drink, or drugs, are adulterated, cause a complaint to be made, and take the other proceedings prescribed by that Act.

"(9.) He shall give immediate notice to the medical officer of health of the occurrence within his district of any contagious, infectious, or epidemic disease of a dangerous character ; and whenever it appears to him that the intervention of such officer is necessary in consequence of the existence of any nuisance injurious to health, or

of any overcrowding in a house, he shall forthwith inform the medical officer thereof.

"(10.) He shall, subject in all respects to the directions of the sanitary authority, attend to the instructions of the medical officer of health with respect to any measures which can be lawfully taken by him under the Sanitary Acts for preventing the spread of any contagious, infectious, or epidemic disease of a dangerous character.

"(11.) He shall enter from day to day, in a book to be provided by the sanitary authority, particulars of his inspections and of the action taken by him in the execution of his duties. He shall also keep a book or books, to be provided by the sanitary authority, so arranged as to form, as far as possible, a continuous record of the sanitary condition of each of the premises in respect of which any action has been taken under the sanitary Acts, and shall keep any other systematic records that the sanitary authority may require.

"(12.) He shall at all reasonable times, when applied to by the medical officer of health, produce to him his books, or any of them, and render to him such information as he may be able to furnish with respect to any matter to which the duties of inspector of nuisances relate.

"(13.) He shall, if directed by the sanitary authority to do so, superintend and see to the due execution of all works which may be undertaken under their direction for the suppression or removal of nuisances within the district.

"(14.) In matters not specifically provided for in this order, he shall observe and execute all the lawful orders and directions of the sanitary authority, and the orders of the Local Government Board which may be hereafter issued, applicable to his office."

In some valuable articles which appeared in the *Medical Times and Gazette* in Nov. 1872, on the duties of medical officers of health, the following sketch of the daily routine in a large metropolitan parish is given as a guide for commencing health officers:—

"At 9 A.M. the subordinate officers arrive at the office. They consist of a clerk, a messenger (who is always a copying clerk), the sanitary inspectors, to each of whom a district is assigned, and a disinfector. Shortly after the medical officer arrives, reads his

letters, confers with the clerk, gives directions as to the correspondence of the day, receives verbal reports from the inspectors as to the previous day's work, and makes appointments for these officers to meet him at particular places during the course of the day, should his presence be deemed necessary in particular cases. In a few minutes a large amount of routine work can thus be got through, whilst reports for committees, special correspondence, and the examination of the books of the department, can be despatched, say twice or thrice a week, at any convenient time. Between 9 and 10 A.M. each inspector writes out a brief diary of his previous day's work for the information of the medical officer, and instructs the disinfector as to houses where disinfection is required. At 10 the sanitary inspectors depart on their daily rounds, having previously informed themselves as to any new complaints requiring their attention. After their departure the clerk extracts and summarises their diaries, and enters the results in the proper books. The books actually in use are—(1.) The medical officer's diary, in which he briefly enters the dates of visits made, with any particulars he thinks fit. (2.) A book for receiving the complaints of ratepayers and others. (3.) A record of houses in which infectious disease has appeared. (4.) The diaries of the several sanitary inspectors. (5.) A book recording the progress of works, which exhibits at a glance the visits made and the works executed at any particular house. From this the clerk extracts, and presents weekly to the medical officer—(6.) A list of works in arrear. (7.) A report book in which the health officer reports to the sanitary committee all ordinary cases of nuisances uncompleted, together with his recommendations. Further, the sanitary inspectors are provided with forms of notices of nuisances, arranged in books with duplicates, after the manner of a cheque-book. These arrangements may seem complicated. In practice, however, they are found to be simple and effective. Where little or no clerical assistance is furnished, they may be much simplified, and the books reduced in number."

In small urban or rural districts, and in combined districts when special clerical assistance is not required, the only book which it may be necessary to keep beyond filing statistics, reports, and any important official communications, is a diary; but this should always be kept, no matter how meagre the duties may be, because it will be frequently required for reference.

16. *Reports.*—All reports from the health officer to

the sanitary authority should be concise and to the point. The stated reports—weekly, quarterly, or otherwise—will deal chiefly with the vital statistics of the district, and enumerate such proceedings as have been undertaken, according to the provisions of the Sanitary Acts, together with any suggestions which he may deem it to be his duty to lay before the sanitary authority from time to time. He should avoid entering into lengthy disquisitions, because he will have the opportunity, at meetings of the sanitary authority, of answering any questions, and justifying his recommendations, should he be called upon to do so. As far as possible he should base his stated reports on a uniform plan, and he may be quite sure that the briefer they are in their completeness, the more they will be appreciated. Annual reports should embrace all the points indicated in the regulations of the Local Government Board, previously quoted. (For official instructions see Appendix.)

If his reports appear in the public newspapers of the district, as will generally be the case, he should endeavour, without being diffuse, to make them readable and instructive, and whenever he considers it necessary to address the public through this channel, with respect to any sanitary dangers to which they may be specially exposed, it is always advisable that his remarks should, in the first instance, be submitted to the sanitary authority. Although he will find the press to be of great assistance in educating the public in sanitary matters, it need hardly be said that he should avoid entering into controversy, and be very careful not to drag the names of private individuals before the public when his reports are printed.

17. *Official Conduct.*—With regard to his subordinates, the medical officer should endeavour to arouse in them an *esprit de corps,* not doing their work, but seeing that they do it themselves efficiently and readily. He should listen

courteously to any remarks or suggestions which they may make, and if they are trained officers, give them credit for knowing their duties as well as he does his own. In their own sphere they are as sensitive to rebuke as himself, and it should, therefore, never be administered unless it is merited. Any serious delinquency or inefficiency on their part should be laid before the sanitary authority, and those who do perform their duties satisfactorily should be as frankly commended. Above all, punctuality should be insisted on. In cases where the health officer will have to educate sanitary inspectors who are new to the work, it would be desirable that all candidates for such an important post should pass a certain period of probation before their appointment is confirmed by the sanitary authority.

As regards the portion of the community committed to his charge, he should endeavour, conscientiously and to the best of his ability, to fulfil his obligations towards them, and if in practice, he should in no wise shirk his public duty, even at the risk of losing his best patient. In this, as in all other affairs of life and conduct, it will be found that in the long run "honesty is the best policy."

Towards his medical brethren he should religiously observe the ethics of his profession, and act up to the golden rule,—"Do to others as you would be done by." He should endeavour to be on friendly terms with all within his district, and never hesitate to court their assistance and advice when he feels that he may require them in the discharge of his duties. It need hardly be said that all such favours or obligations should be readily and ungrudgingly reciprocated on his part. If he is not debarred from private practice, he should be careful, above all things, not to take advantage of his public office by using it as a means to increase the number of his patients. This, to say the least, would be a grave breach of professional etiquette, which would deservedly arouse re-

monstrance and opposition on the part of his medical brethren.

His relations to the sanitary authority or sanitary committee, as the case may be, should be guided by common sense and a sense of duty. He should always remember that he is their medical adviser, not their dictator; and at their meetings he should carefully avoid taking part in discussions on his reports, unless called upon to do so, or in reply to objections. He should attend all meetings at which his presence is requested or expected; and when he does attend, he should support his views, when called upon, with clearness, firmness, courtesy, and tact. His proposals may be rejected, but if they do not lie within the scope of the statutory enactments requiring their enforcement, he should never resent opposition, but again bring them forward on future occasions. But with regard to breaches of sanitary law, which in spite of his representations may be persistently ignored, he should unhesitatingly insist upon their being remedied, and, failing action, he can always appeal to the Local Government Board. It is to be hoped, however, that he will seldom meet with such unwarrantable opposition. Under all circumstances he should strive to exercise a wise forbearance when he can conscientiously do so, and on all occasions maintain a courteous, dignified, and friendly demeanour towards the sanitary authority, feeling assured that tact and good temper, like good words, "are worth much and cost but little."

APPENDIX

OFFICIAL MEMORANDA AND OTHER DATA

I.—Annual Reports of Medical Officers of Health.

Instructions.—Every medical officer of health, appointed under the order of the Local Government Board dated the 11th November 1872, is required to make an annual report with regard to each sanitary district, or division of a district, which is under his superintendence. This report is to be for the year ending the 31st of December, or, if the officer at that date has not been in office for a whole year, then for so much of the year as has elapsed since his appointment. The report is to be made to the sanitary authority, and a copy of it is to be sent by the medical officer of health to the Local Government Board. It should be made as soon as practicable after the expiration of the year to which it relates. The medical officer of health ought not, in general, to have any difficulty in doing this within a month or six weeks; but if from any special circumstances the report cannot be completed within six weeks, it should be understood that the delay must not be indefinite, and that the report, complete or incomplete, should be in the hands of the sanitary authority within, at most, three months from the end of the year. The Board's copy of the report should be forwarded to them when the original is sent to the sanitary authority, except where the report is likely to be printed by order of the authority. In such cases the Board need only be supplied with a printed copy. But in all cases in which the report cannot be sent to the Board within six weeks from the end of the year, they should be informed by the medical officer of health as to the reason for the delay.

Article 14 of Section IV. of the Board's Order provides that the annual report is to contain information as to the sickness and deaths that have occurred during the year; the measures taken in order to prevent the spread of disease; and the proceedings of the medical officer of health. It would be well if the report, so far as it relates

to the medical officer of health's proceedings, were, in the main, the same in arrangement as the articles which deal with these proceedings ; thus stating first what has been done under articles 1-3, which make it the duty of the medical officer of health to inform himself as to the sanitary state of the district, and to make the inquiries and inspections necessary for this purpose ; next, the advice which has been given to the sanitary authority under articles 4 and 5 ; and lastly, the action he has taken under articles 6-10 in the several matters therein referred to.

As regards the duties imposed under these several articles, each of which will thus be reported on, special attention should be had to the provisions of article 3, which directs systematic inspections of the district to be made by the medical officer of health, apart from the inquiries which under other articles of the Order he has to make into particular outbreaks of disease, or into unwholesome conditions to which his attention may have been specially called by complaints or otherwise. The object of these systematic inspections is that the medical officer of health may assure himself that he is well acquainted with all the discoverable circumstances which are likely to affect the public health in his district. How often these inspections require to be made, and how detailed the inquiries should be, must be determined by the particular circumstances of the locality. In some neighbourhoods a house-to-house inspection should as far as practicable be made ; in others this may not be needful ; but every medical officer of health should at certain times set himself to examine into the state of his district, devoting some time to each portion of it, so as to be sure that no part escapes his notice. In making such an inspection the medical officer of health will usually require the assistance of the inspector of nuisances. Of these inspections, of the judgment he has formed thereon as to the sanitary state of the district, and of the advice he has in consequence given to the sanitary authority, and the action taken by the authority thereon, the annual report should contain a full account.

As regards the tabular statements of sickness and mortality (forms for which statements are now issued by the Board) only one observation appears to be needful. The district under the superintendence of a medical officer of health will often contain several parts evidently differing in their circumstances, or having very different death-rates, either of all registered deaths, or of those from some particular disease or class of diseases. The observation of these differences can scarcely fail to lead to valuable information, and it is in view of those differences that in article 14 the tabular statements are required to be classified according to *localities*, and that provision

for such a classification is made in the enclosed forms for returns of deaths. In the absence of any ascertained differences of the above sort, it will still be desirable to classify the deaths of the district according to the part of the district in which they occur; and for this purpose any areas of known population (such as parishes, groups of parishes, townships, or wards) may be taken as representing "*localities*" for the purposes of the Order. Classification on this basis will be likely to lead to the discovery of real differences when the returns for several years can be compared together.

Having regard to the imperfect character of the information which is obtainable as to non-fatal sickness, such a classification cannot, it seems, be generally attempted in the sickness returns; but in particular cases medical officers of health may be able, and may find it useful, so to classify the pauper sickness of which they receive information.

What has been said above with regard to the information which an annual report should contain must be understood, not as suggesting that the report should be limited to these subjects, or that more detailed or differently arranged tabular statements may not be added, but as indicating the minimum of information which will satisfy the requirements of the Board's Order. Many medical officers of health will doubtless, and with great advantage to the administration of their district, give much more detailed information than they are actually required to furnish, and will give especial prominence to the questions to which they have been led by the circumstances of the past year to devote particular attention, or in the investigation of which they may have arrived at valuable conclusions. Any information of this kind will be gladly received by the Local Government Board.

EDWARD C. SEATON, M.D.,
Medical Officer.

Local Government Board, December 1877.

II.—MEMORANDUM on the STEPS specially requisite to be taken by BOARDS of GUARDIANS under the VACCINATION ACTS, 1867 and 1871, in places in which SMALL-POX is EPIDEMIC.

As it is by vaccination that the spread of smallpox can most effectually be prevented, Boards of Guardians, as soon as any case of that disease is brought into or occurs in their respective Unions or Parishes, should see that measures are promptly taken to secure,

as far as necessary, the vaccination (or, as the case may be, re-vaccination) of all such persons as are especially exposed to the danger of the infection.

Under the Order of Privy Council of February 18, 1868 (Reg. I. Art. 1), the public vaccinator is authorised to vaccinate, elsewhere than at the public station, cases in which there exists a special reason (to be noted by him in his register) for taking this exceptional course ; and sec. 13 of 34 and 35 Vict. cap. 98, provides that district medical officers in attendance upon any person suffering from smallpox shall be entitled to payment from the Guardians for vaccinating or (as the case may be) re-vaccinating any person who is resident in the same house as such sick person, and who could lawfully be vaccinated or (as the case may be) re-vaccinated by a public vaccinator at the public expense.

These provisions, promptly applied on the occurrence of any isolated case or cases of smallpox, will in general be found adequate to stop the further spread of the disease ; but if from neglect of them or from any other circumstances, cases of smallpox shall have become numerous, special measures (as below explained) should be taken to expedite, as far as practicable, the vaccination of all unvaccinated persons in the district, and to promote the re-vaccination of adults and adolescents who have not already been successfully re-vaccinated ; and special arrangements (as below explained) may also be requisite to facilitate the performance of public vaccination and re-vaccination.

This Memorandum is intended to afford information on those measures and arrangements.

Special Instructions to Vaccination Officers.

1. At times when smallpox is epidemic, the vaccination officer should give his first and special attention to the particular localities in which the infection exists.

2. In order that for this purpose he may have the earliest possible information of the occurrence of cases of the disease, the Guardians should instruct their district medical officers to give him immediate notice of every fresh case of smallpox which comes under their treatment, and should also arrange with the registrars of deaths to forward to him immediate notice of each death registered from smallpox. For convenience of transmitting such notices, each district medical officer and Registrar should be supplied with forms duly stamped for post, or with post-cards adapted for the purpose. Private medical practitioners should also be invited to give similar information.

3. In each locality in which the infection exists, the vaccination officer should with the utmost possible despatch personally ascertain what children are unprotected by vaccination, and should use his utmost exertions to obtain the prompt vaccination of all such children. Generally speaking, his own judgment and local knowledge will guide him as to the manner in which his inquiries can best be made ; but in infected courts or alleys, as well as certain kinds of streets, inquiries from house to house, and in tenement-houses from room to room, will be indispensable.

4. Where any child (between the ages of 3 months and 14 years) is found illegally unvaccinated, the vaccination officer should give a notice requiring the vaccination to be done within a specified period. This period, when there is smallpox in the house, or other special risk of exposure to the contagion, should not exceed twenty-four hours ; but in other cases some days, not exceeding a week, may be allowed. A second visit from the vaccination officer will, of course, afterwards be necessary in order to see that his notice has been complied with.

With regard to unvaccinated children not yet three months old, who may be in infected localities, the vaccination officer should advise the parents not to incur the unnecessary risk of waiting for the child to complete that age before having its vaccination performed ; for vaccination is perfectly well borne by children even immediately after birth. In no house in which there is smallpox ought a child, however young, on any account to remain unvaccinated, unless on medical examination it be pronounced unfit to be vaccinated.

5. The vaccination officer should make it well known in infected localities that the public vaccinator is at liberty to re-vaccinate grown-up and young persons (not under 12 years of age) who have not before been successfully re-vaccinated, and who apply to him for that purpose ; and that persons not vaccinated since childhood, who are likely to be exposed to contagion, ought to be re-vaccinated without delay. Above all, this is necessary for persons whose original marks of vaccination are imperfect.

6. All notices given and representations made as above should be accompanied with information as to the provisions made for public vaccination in the district. If any case requiring prompt vaccination by the public vaccinator cannot, in the judgment of the vaccination officer, properly be taken to the station or to the residence of the public vaccinator, the vaccination officer should give to the public vaccinator immediate information of the case.

7. Besides the above described special proceedings in localities already infected, the vaccination officer should take every means to

ensure that the vaccination of his district generally is as complete as possible. He should make frequent examination of his birth-lists, and deal, as soon as practicable, with every default as it arises ; and he should be prompt and diligent in his inquiries respecting the other children to whom his duties extend under section 12 of his "instructions," as issued by the Local Government Board.

III.—Re-Vaccination.

By vaccination in infancy, if thoroughly well performed and successful, most people are completely insured for their whole life-time against an attack of smallpox ; and in the proportionately few cases where the protection is less complete, smallpox, if it be caught, will, in consequence of the vaccination, generally be so mild a disease as not to threaten death or disfigurement. If, however, the vaccination in early life have been but imperfectly performed, or have from any other cause been but imperfectly successful, the protection against smallpox is much less satisfactory ; neither lasting so long, nor, while it lasts, being nearly so complete as the protection which first-rate vaccination gives. In consequence of the large amount of imperfect vaccination which has till very recent years existed, the population contains very many persons who, though nominally vaccinated, and believing themselves to be protected against smallpox, are really liable to infection, and may, in some cases, contract as severe forms of smallpox as if they had never been vaccinated. Partly because of the existence of this large number of imperfectly vaccinated persons, and partly because also even the best infantine vaccination sometimes in process of time loses more or less of its effect, it is advisable that *all persons who have been vaccinated in infancy should, as they approach adult life undergo* RE-VACCINATION. Generally speaking, the best time of life for re-vaccination is about the time when growth is completing itself, say from 15 to 18 years of age ; and persons in that period of life ought not to delay their re-vaccination till times when there shall be special alarm of smallpox : first, because they can never tell how soon, or by what chance, they may (even at times when there is little prevalence of that disease) be exposed to its infection ; and secondly, because of the much more advantageous conditions under which the re-vaccination can be performed when it can be done leisurely, than when it has to be done under the pressure caused by a panic. When, however, smallpox becomes epidemic, not only should all persons above 15 years of age who had hitherto neglected to have themselves re-vaccinated be very careful to

neglect it no longer, but in proportion as there is prevalence of smallpox in any neighbourhood, or as individuals are from personal circumstances likely to meet chances of infection, even the age of 15 should not be waited for, especially not by young persons whose marks of previous vaccination are unsatisfactory. *The rule applicable to circumstances of special danger is this: that every one past childhood on whom re-vaccination has not before been successfully performed, should without delay be re-vaccinated.*

Re-vaccination, once properly and successfully performed, *does not appear ever to require repetition.* The nurses and other servants of the London Smallpox Hospital, when they enter the service (unless it be certain that they have already had smallpox), are invariably submitted to vaccination, which in their case generally is re-vaccination, and is never afterwards repeated ; and so perfect is the protection that, though the nurses live in the closest and most constant attendance on smallpox patients, and though also the other servants are in various ways exposed to special chances of infection, the resident surgeon of the hospital, during his forty-one years of office there, has never known smallpox affect any one of these nurses or servants.

Legal provisions for re-vaccination are made in the 8th Section of the Vaccination Act, 1867, in Section IV. of the Regulations which the Lords of the Council, under authority of that Act, issued in their order of February 18, 1868, and in the 9th Section of the Vaccination Act, 1871. Under these provisions, *Re-vaccination is now performed by all public vaccinators at their respective vaccinating stations;* and, so far as is not inconsistent with the more imperative claims for primary vaccination, *any person coming within the terms of these provisions may, on applying to the public station of the district in which he resides, obtain re-vaccination free of personal cost.*

EDWARD C. SEATON, M.D.,
Medical Officer.

Local Government Board, October 17, 1876.

Section VIII. of the Vaccination Act, 1867, is as follows :— "The provisions of the contracts entered into before this Act comes into operation shall not, after the thirty-first day of December next, apply to the cases of persons who, having been previously successfully vaccinated, shall be re-vaccinated ; but if the Lords of Her Majesty's Council shall have issued or shall hereafter issue regulations in respect of the re-vaccination of persons who may apply to be re-vaccinated, which such Lords are hereby authorised to do, the

guardians shall pay, in respect of every case of successful re-vaccination performed in conformity with such regulations under such contracts or under new contracts entered into after the date hereof, a sum amounting to two-thirds of the fee payable upon each case of successful primary vaccination."

Section IV. of the Regulations issued by the Lords of the Council in their Order of February 18, 1868, is as follows :—"The performance of re-vaccination by the public vaccinator on persons applying to him for that purpose shall be limited in each case by the following conditions—(1) that, so far as the public vaccinator can ascertain, the applicant has attained the age of fifteen years, or if, during any immediate danger of smallpox, the age of twelve years, and has not before been successfully re-vaccinated ; and (2) that, in the public vaccinator's judgment, the proposed re-vaccination is not for any sufficient medical reason undesirable ; and (3) that the public vaccinator can afford vaccine lymph for the purpose without in any degree postponing the claims which are made on him for the performance of primary vaccination in his district."

Section IX. of the Vaccination Act, 1871, is as follows :—"Where the operation of re-vaccinating any person is performed on the application of such person by the public vaccinator without charge to such person, the public vaccinator shall deliver to such person a notice requiring him to attend at the same place on the same day in the following week, in order that he may be inspected and the result of the operation ascertained, and stating that in default he will be liable as in this section mentioned, and the public vaccinator, if required, shall deliver to the person re-vaccinated a certificate of the result of the operation of re-vaccination ; and if such person fail to comply with such notice, or to permit the public vaccinator or his deputy to ascertain the result of the operation, he shall pay a fee for such re-vaccination of two shillings and sixpence, which fee shall be a debt due from him to the guardians of the union or parish in which such public vaccinator acts, and all such fees shall be paid to and all expenses of the guardians incurred under this section shall be paid out of the fund out of which the expenses of the guardians under the principal Act are paid."

IV.—Memoranda, on the Closing of Public Elementary Schools or the Exclusion therefrom of particular Children in order to prevent the Spread of Disease.

1. It is attempted in these notes to bring together the information in the possession of the Local Government Board, derived from

the reports of the Board's own Medical Inspectors and of local Medical Officers of Health, respecting school-closure and exclusion from school as precautions against infection. It is sought to indicate the best means of preventing the spread of disease by school children among their fellows, while avoiding any unnecessary interruption of the work of education.

2. In the Code of Regulations approved by the Lords of the Committee of Council on Education on the 3d March 1884, the following Article (Art. 98) prescribes as one of the general conditions required to be fulfilled by a Public Elementary School in order to obtain an annual Parliamentary grant that—

"The Managers must comply with any notice of the sanitary authority of the district in which the school is situated, requiring them for a specified time, with a view to preventing the spread of disease, either to close the school or to exclude any scholars from attendance, subject to an appeal to the Department, if the managers consider the notice to be unreasonable."

To facilitate compliance with this Article, certain other provisions are made (Arts. 94, 95, 102).

Article 96 (*a*) is also of importance in connection with questions of disease prevention.

The Education Department must be satisfied "that the school premises are healthy, well lighted, warmed, drained, and ventilated, properly furnished and supplied with suitable offices, and contain sufficient accommodation for the scholars attending the school.

"N.B.—In administering this article the Department will endeavour to secure at least 80 cubic feet of internal space and 8 square feet of internal area for each unit of average attendance; . . ."

3. The diseases for the prevention of which school closure, or the exclusion of particular children, will be required are principally those which spread by infection directly from person to person, such as scarlet fever, measles, diphtheria, whooping-cough, small-pox, and rötheln, the order in which the several diseases are here given being about that of the relative frequency with which their occurrence gives rise to these questions at schools. More rarely, the same questions arise in connection with enteric fever and diarrhœal diseases, which spread not so much by direct infection from person to person as indirectly through the agency of local unsanitary conditions, such as infected school privies.

Such further and peculiar relations between school and infection as are suggested by recent reports on diphtheria do not need consideration for the immediate purposes of these memoranda.

4. It will be seen that Article 98 quoted above confers upon sanitary authorities an alternative power with respect to public elementary schools—

(*a*) To require the school to be closed for a specified time, or

(*b*) To cause particular scholars to be for the specified time excluded from attendance.

5. It will be convenient *first* to consider the circumstances under which the requirements of the public health for preventing the spread of disease will be satisfied by the less severe measure of the *exclusion from* school of particular children.

It may be laid down as a universal principle that all children suffering from any dangerous infectious disorder (*i.e.* of a nature dangerous to some of the persons attacked by it, however mild in other cases) should be excluded from school until there is reason to believe that they have ceased to be in an infectious condition (see Section 126 of the Public Health Act, 1875).

Furthermore, as it is rarely possible to provide effectual isolation of the sick from the healthy within the homes of children of the class attending public elementary schools, it must commonly be necessary that all children of an infected household should be excluded from school ; first, because otherwise such children might attend school while suffering from the disease in a latent form, or at an unrecognised stage, and secondly, because it is known that infection may attach itself to, and be conveyed by, the clothes of a person living in an infected atmosphere, even though the person himself remain unaffected. The same considerations will sometimes make it desirable to prohibit the attendance at school of all children from a partciular street or hamlet.

In the case of infectious diseases involving little or no danger to life, such as mumps or skin diseases, school interests may be more particularly considered in determining the exclusion of scholars. In such case, however, the rule of prohibiting the attendance of every child while in an infectious state will commonly prove to be the right one ; for if disease should spread to other scholars owing to the continuance of an infected child at the school, there will be greater ultimate loss of attendance with corresponding loss of credit to the school.

6. The Medical Officer of Health, on becoming aware of the presence of dangerous infectious disease in his district, should send immediate notice to the teacher of the school or schools which the children of infected households may be attending, requesting that such children may be excluded from school for such time as he (the Medical Officer of Health) may specify as being necessary. (*See*

Articles 2 (7) and 18 (6) of the Board's General Orders prescribing the duties of Medical Officers of Health.)

Frequently, the school attendance officer or the schoolmaster himself will obtain the earliest information of the occurrence of infectious disease among scholars, and it is most desirable that such officer or master should without delay communicate the facts to the Medical Officer of Health. Absence of any child from school on the plea that it is suffering under one of the before-mentioned diseases, and absence of several children of one family from school at the same time, no matter what name be given to the complaint that keeps them at home, should be reported to the health officer. In practice it has been found that this notification of absentees has materially aided the local health officer in taking measures for the suppression of infectious disease, to the advantage alike of the district and of the school. Furthermore, schoolmasters may properly be asked to take note, especially when an epidemic threatens or is present, of symptoms occurring in any of their scholars that may indicate the commencement of disease, febrile in nature. Such symptoms are shivering, headache, and languor, especially if commencing suddenly, vomiting, rashes on the skin, and sore throat. When scarlet fever or diphtheria is about, every trace of sore throat should be looked upon as suspicious. In any case where such symptoms are observed, the safest course will be to exclude the child from school until assurance can be had that it may attend school without harm to itself or danger to other scholars.

7. The time to be specified, during which the exclusion from school of particular children is to last, will vary in different diseases and different cases, and in this matter the sanitary authority will doubtless be guided by the advice of their Medical Officer of Health, who may properly be entrusted with some general duty of acting for the authority in this subject matter.

Medical officers of health, having to specify a time during which any scholars are to be excluded from attendance at any school, should have regard as far as practicable to the circumstances of the particular scholars suffering from infectious disease or living in infected households. Not only the nature of the infection and the length of illness, but the environments of the individual as affecting the retention of infection will deserve consideration. The period of exclusion, for example, will need to be different according to the conditions of a patient's lodgment, according to the sufficiency of the separation that can be effected between a patient and excluded scholars, and according to the opportunities of effectual disinfection

that can be afforded to the household. Thus a hard and fast rule, such as has been laid down in some districts where scarlatina has been present, that no child shall go to school from an infected house for three months after the disease has begun in that house, is not to be commended. It is indeed possible that under the circumtances of a particular household, a child convalescent from scarlatina or living in the same house with convalescents should not in the interests of other children be permitted to return to school until after so long a period as this ; but the same ought not to be assumed of all households in the district that may be invaded by scarlatina. The better plan would be for the sanitary authority to secure, during a shorter period, the exclusion of individual sick persons and their housemates from school ; and when that period is about to expire to cause fresh inquiry to be made as to the expediency of further exclusion, and, if found requisite in particular cases, to cause fresh notice to be given to the school managers.

8. *Secondly*, as to the *closing of schools.* This, by more seriously interfering with the educational work of a district, is a much more grave step for a sanitary authority to take than to direct the exclusion of particular scholars. It is a step that seldom ought to be enforced, except in presence of an actual epidemic, nor even then as a matter of routine, nor unless there be a clear prospect of preventing the propagation of disease, such as could not be looked for from less comprehensive action.

> The mere fact that in an epidemic many of the sufferers are school children does not necessarily show that the disease was caught at school ; but the school may with probability be regarded as spreading infection if in a large majority of households attacked the first case be a child attending school ; and with still greater probability if a number of children living at a distance from one another, and with no circumstances in common, except that they attend the same school, should be simultaneously attacked, and if it can be ascertained that a child or teacher in an infectious state has actually been attending the school.

9. In deciding whether an outbreak of infectious disease among children of school age may be best combated by closing the school, or whether it will suffice to exclude the children of infected households, the two most important points to be considered are :—

(*a.*) The completeness and promptness of the information received by the officers of the sanitary authority respecting the occurrence of infectious cases.

(*b.*) The opportunities which exist for intercourse between the children of different households elsewhere than at school.

10. (*a.*) The more prompt and full the knowledge of cases of infectious disease that the sanitary authority are able to obtain, the better will be the prospect of checking such disease by keeping away from school the children of infected households, and the less will be the necessity for closing schools. If the cases be few in number, and their origin known, the exclusion from school of the children of infected households will probably suffice ; but this measure will fail where there are many undiscovered or unrecognised cases, or where the known centres of infection are peculiarly numerous.

Commonly, the failure of carefully considered measures of exclusion to stay the spread of an epidemic which shows a special incidence upon school children, may be regarded as pointing to the continued attendance at school of children with the prevalent disease in a mild or unrecognised form, and a strong case will appear for the closing of schools.

If by reason of the absence or exclusion of a large number of children, the attendance at a school be greatly reduced, it may be found better to close it altogether. This is especially apt to occur in the case of epidemics of measles, a disease which is very infectious in the early stages, before the characteristic rash has appeared, and while the symptoms are only those of a common cold.

> In a village where a medical practitioner purposely concealed the existence of scarlatina among his patients, the exclusion from school of children living in those houses that the sanitary authority knew to be infected failed to check the prevalence of the disease, but it began to decline as soon as the schools were closed.

11. (*b.*) The second material consideration, in deciding as to the desirability of closing schools during the prevalence of infectious disease, is the amount of opportunity for intercommunication between the members of different households elsewhere than at school. In sparsely populated rural districts, where the children of different households or of separate hamlets rarely meet except at, or on their way to, the village school, the closing of the school is likely to be effectual in checking the spread of disease. It is less likely to be useful in a town or compact village (particularly where houses are sublet and yards are in common), where the children of different households, when not at school, spend their time in playing together, and often run in and out of each other's houses. In some such places the closing of schools has even appeared to do harm rather than good.

In rural districts, where epidemic diseases are less frequently prevalent, school managers may more fairly be asked to close their schools, as an exceptional measure to meet an exceptional state of things. As regards more populous places, it must not be forgotten that if schools were to be closed whenever an infectious disease was prevalent, there are many places where schools would hardly ever be open.

12. It will sometimes be necessary to close a school for a day or two to allow of the rectification of sanitary defects of a nature to extend disease, or in order that the school may be disinfected or purified. It has happened that infectious sickness in the master's family has forbidden the attendance of scholars. These more temporary and occasional closures of schools are contemplated in the before-quoted section of the Education Code, and are to be regarded as having a real importance of their own.

Formal processes of cleansing and disinfection will be especially wanted if children in an infectious condition have actually been attending school. It is to be desired that the details of them should be defined by the Medical Officer of Health, at whose instance they are taken, and that they should be executed to his satisfaction.

As a precautionary measure, during the prevalence of an epidemic the fumigation of the schoolroom every week by burning sulphur may be recommended, and may usually be done on Saturdays without interruption of school duties.

As regards enteric fever and other diseases attended with diarrhœa, it is not to be forgotten that such diseases can spread through school privies that have become infected by the discharges of a commencing or unrecognised case. When such diseases are prevalent, school privies should be frequently emptied and cleansed, and such disinfectant as the Medical Officer of Health may advise should be applied to them according to his instructions and in liberal quantity.

The sanitary defects of schools, likely to assist in the propagation of disease, are most usually found to be uncleanly condition, want of ventilation, untrapped waste pipes from lavatories, bad construction, bad position, or foul condition of closets. Ventilation is a matter so important in the present connection that it may be well to note here that every schoolroom should be adequately furnished with means of ventilation of two kinds, viz. (*a*) apertures for the supply, during school time, of a steady volume of air without draughts; and (*b*) windows made to open on two sides of the room so that the

whole aërial contents of the room may be thoroughly changed in the intervals between school hours.

The principles to be held in view in the construction of school privies are set forth in a memorandum, issued by the Committee of Council on Education, entitled "Practical Suggestions as to the Construction and Cleansing of School Offices."

A supply of wholesome water should be secured to every school. Epidemics at schools have been traced to the drinking of contaminated water furnished from school wells or obtained from neighbouring sources.

In places where children have to come from a distance, and do not go home for their midday meal, a room should be open for their use during the interval between morning and afternoon school, or they will seek shelter where they can,—perhaps in infected houses.

13. In places where there are several public elementary schools, if an outbreak of infectious disease be confined to the scholars of one particular school, it may be sufficient to close that school only. But where different schools have all appeared to aid in the spread of disease (though perhaps to an unequal extent) the sanitary authority may consider it advisable that all should be closed, not only for the sake of appearing to deal with all impartially, but also lest children in an infectious state who previously attended the schools that are closed, should be sent to others that might remain open.

It must be remembered that sanitary authorities have no power in respect of Sunday schools, or dames' or other private schools: except in so far as these may contravene sect. 91 (5), sect. 126, or other provision of the Public Health Act; and the closing of Public Elementary Schools may tend to undue crowding in dames' schools.

14. Notices of the sanitary authority for the closing of Public Elementary Schools should be made in writing to the managers, and should state the grounds on which the closing is deemed necessary.

All such notices should specify a definite time during which the school is to remain closed; this should be as short a period as can be regarded as sufficing on sanitary grounds; a second notice may be given before the expiration of the first, if it should be found necessary to postpone the re-opening of a school. The managers of schools have an appeal to the Education Department, if they consider any notice to be unreasonable.

15. In conclusion two general observations may be made.

First, that in proportion as the sanitary authority have performed their own proper work for the protection of their district from infectious diseases,—as they have secured early information of the occurrence of cases ; as they have provided accommodation for the isolation of such cases, and arranged for keeping patients under supervision until their infectious condition has ceased ; and as they have provided for the subsequent disinfection of infected houses and things,—the more successfully will they be able to deal with such diseases when they occur, without the serious interference with the business of popular education involved in the compulsory closing of schools.

Secondly, that the proper work of schools is facilitated and the credit of the school is promoted by every measure which hinders the spread of infection. Wherefore it is entirely in the interests of school managers themselves to trust the skilled judgment of sanitary authorities, and to aid their endeavours to maintain the public health. GEORGE BUCHANAN.

Local Government Board, June 1884.

V.—SUGGESTIONS for Preventing the spread of DANGEROUS INFECTIOUS DISEASES, such as SMALLPOX, SCARLET FEVER, FEVER, etc. (*By the Author.*)

1. When a case of dangerous infectious disease occurs, or is suspected, a medical practitioner should be immediately sent for. No suspected case should be taken to a dispensary or hospital for advice, or from any house where dangerous infectious disease exists.

2. Whenever a patient cannot be sufficiently isolated from the rest of the family or household, he should, if possible, be removed to a hospital for infectious disease, wherever such hospital accommodation is provided, but only under advice, or by permission of the medical attendant.

3. No householder or employer of labour can send servants suffering from any dangerous infectious disease to their own homes, without rendering himself liable to be prosecuted by the sanitary authority of the district, unless all due precautions are taken.

4. If the disease is smallpox, any unvaccinated infant in the house should at once be vaccinated ; and all adults, or young persons over twelve years of age, or children with indistinct vaccine marks, should be revaccinated. The same precautions should also

be carried out in respect to persons in the immediately adjoining houses.

5. When the patient is not removed to a hospital, a room at the top of the house, well-lighted, well-ventilated, well-warmed, and sufficiently well isolated, should always, if possible, be selected for the sick-room, and care should be taken to remove all carpets, curtains, needless draperies, and unnecessary pieces of furniture or clothing.

6. If the patient cannot be removed to a hospital, nor sufficiently isolated, the house should be quarantined as far as possible, by providing adequate nursing and attendance ; and whenever it can be done, the other members of the family who have not been exposed to infection should be removed elsewhere.

7. Persons in attendance on the sick should by preference wear cotton dresses, maintain scrupulous cleanliness, and should avoid as far as possible from associating with others. If the case is one of smallpox, the persons in attendance should be protected either by a previous attack, or by revaccination.

8. Disinfectants which have no unpleasant odour may be sprinkled about the room ; but the best of all disinfectants for the air is free ventilation by open windows, and a fire if necessary. To complete the isolation of the room and sweeten the air, a sheet steeped in some disinfectant solution should be suspended outside the door of the room.

9. All discharges from the patient, especially if the disease be smallpox, scarlatina, or typhoid fever, should be received into vessels containing some suitable disinfectant (crude carbolic acid, 1 pint to 2 gallons of water), and should be removed from the sick-room without delay. If disinfectants are not speedily procurable, boiling water should be poured over the discharges. In country districts it is advisable that all discharges should be buried in a hole dug in the garden, but at a safe distance from the well.

10. Soft pieces of rag should be used for wiping the mouth and nose of the patient when deemed necessary, and these should either be burned or plunged into some vessel containing water charged with a disinfectant (carbolic acid solution), or steeped in boiling water, and removed without delay.

11. All bed or body linen which has been in contact with the person of the patient should be received into a vessel containing water charged with a disinfectant (carbolic acid solution) before removal from the room, and afterwards boiled.

12. All glasses, cups, or other vessels used in the sick-room,

should be washed in hot water, and scrupulously cleaned before being used by others.

13. In cases of scarlet fever or smallpox, the body of the patient should be rubbed all over with carbolised or camphorated oil daily, so soon as approved by the medical attendant; and when the patient is able to take a warm bath, the whole of the body should be well bathed with warm water and disinfectant soap. These baths should be continued under the advice of the medical attendant, until such time as he may consider the patient entirely free from infection, after which, and in clean clothes, he may be allowed to rejoin the family and mix with others, but not till then. The patient cannot be pronounced absolutely free from conveying infection until all peeling has entirely ceased in scarlet fever, and until the crusts and scales have been removed in smallpox, and the whole of the body has been well bathed. Indeed, in all cases of infectious disease, the patient should have one or more warm baths before putting on clean clothes.

14. The sick-room should not be visited by any but those in attendance on the patient, as the clothing of visitors is very liable to convey infection.

15. When the illness has terminated, the sick-room and its contents should be thoroughly fumigated and disinfected. This is best effected in the following manner :—Spread out and hang over lines stretched across the room all articles of clothing and bedding ; stop up the chimney flue, and well close the windows and other openings ; then take lumps of sulphur well broken up (about 1 lb. to every 1000 cubic feet of space), place them in an iron dish (or the lid of an iron sauce-pan), supported on a pair of tongs over a bucket of water, and set fire to the brimstone. The door should then be shut and all crevices stopped up, and the room kept closed for at least six hours. After fumigation, the room should be freely ventilated, the wall-paper, if any, removed, the walls and ceiling lime-washed, and the floor and furniture washed with carbolic acid soap and water. The bedding, mattresses, and articles which cannot well be washed should be sent to a disinfecting chamber, wherever such chamber is provided by the sanitary authority. Failing this, all articles should be well teased out and fumigated in the sick-room ; such of them as can be steeped in water should be steeped in a strong solution of carbolic acid, and all of them freely exposed to the air afterwards. Soiled bedding and mattresses which cannot be properly disinfected should be destroyed, or buried with disinfectants thrown over them in a hole dug in the garden.

16. No clothes should be sent from any house where dangerous

infectious disease exists to be washed elsewhere ; nor, if clothes are received to wash, should they be received until the house is pronounced free from infection.

17. On no account should any children belonging to a house where dangerous infectious disease exists be allowed to go to school or mix with other children, and the rest of the family should, as far as possible, avoid associating with others.

18. The greatest care should be taken to remove all nuisances from the premises. No filth accumulations should be tolerated, and disinfectants should be freely used for closets, whether outside or inside. Drains should be kept well flushed and disinfected. Above all, the water supply should be examined if obtained from a private well.

19. In case of death, the body should be completely enveloped in a sheet steeped or wrung out of a strong solution of some powerful disinfectant (1 pint of crude carbolic acid to 1 gallon of water), placed in a coffin with a pound or two of carbolic acid powder sprinkled over it, fastened down, and buried without delay. On no account should the body be removed from the sick-room except for burial, unless to a mortuary, and as few persons as possible should attend the funeral.

20. Early information of every case of infectious disease should be forwarded to the medical officer of health, or to the sanitary inspector of the district, who is generally authorised to supply disinfectants to all who are too poor to buy them.

21. Although it may not be possible to carry out these precautions in all cases, it ought to be the duty of every responsible person to strive to do so.

Penalties.

By provisions of the Public Health Act, 1875, it is enacted as follows :—

1. Any person suffering from any dangerous infectious disorder, who wilfully exposes himself in any street, public place, shop, inn, or public conveyance, or enters any public conveyance without previously notifying to the owner, conductor, or driver thereof, that he is so suffering ; or being in charge of any person so suffering, so exposes such sufferer ; or gives, lends, sells, transmits, or exposes without previous disinfection, any bedding, clothing, rags, or other things which have been exposed to infection from any such disorder, shall be liable to a penalty not exceeding £5.

2. Every owner or driver of a public conveyance shall im-

mediately provide for the disinfection of such conveyance after it has to his knowledge conveyed any person so suffering from a dangerous infectious disorder ; and if he fails to do so he shall be liable to a penalty not exceeding £5.

3. Any person who knowingly lets for hire any house, room, or part of a house in which any person has been suffering from any dangerous infectious disorder, without having such room, or part of a house, and all articles therein liable to retain infection, disinfected to the satisfaction of a legally qualified medical practitioner, shall be liable to a penalty not exceeding £20.

For the purposes of this section, the keeper of an inn shall be deemed to let for hire part of a house to any person admitted as a guest into such inn.

4. Any person letting for hire, or showing for the purpose of hire, any house or part of a house, who, on being questioned by any person negotiating for the hire of such house or part of a house as to the fact of there being, or within six weeks previously having been therein, any person suffering from any dangerous infectious disorder, knowingly makes a false answer to such question, shall be liable, at the discretion of the court, to a penalty not exceeding £20, or to imprisonment with or without hard labour for a period not exceeding one month.

5. It is further enacted that the owner or occupier, on notice being given, shall be required to disinfect any house or room, or the cabin or berth of any ship or vessel, and the articles contained therein likely to retain infection—where infectious disease has existed—under a penalty not exceeding 10s. per day for neglect.

VI.—Memorandum with respect to Returns of Deaths from Registrars and Returns of Pauper Sickness from District Medical Officers.

Under Articles 14 and 15 of Section IV. of the General Order of the 11th November 1872, every medical officer of health whose appointment has been approved by the Board is required to prepare an annual report, comprising, amongst other things, tabular statements of the mortality and of the pauper sickness in his district. Information as to mortality and sickness is required by the medical officer of health not only in preparing these statements, but also in discharging the duties of his office, and this Memorandum is intended to indicate the arrangements which should be made for furnishing him with such information.

1. The sanitary authority should, under section 28 of the

Births and Deaths Registration Act, 1874, require the Registrars of Births and Deaths to supply returns of the deaths registered within their respective districts. These returns should be made weekly as regards all deaths registered as having occurred within the Registrar's district during the preceding week ; but an immediate notice should be given of all deaths from infectious disease in fresh localities, and of all groups of deaths from such disease, or from diarrhœa, in any localities. The Registrar-General has prepared for the use of Registrars a form in which the weekly returns may be conveniently made. A fee of twopence for each entry is payable by the sanitary authority.

2. The medical officer of health should be regularly supplied with information of the new cases of pauper sickness in his district. This information is valuable to him, not only as an index to the prevalence of non-fatal disease among all classes in the sanitary district, but as giving him occasion to exercise useful and immediate sanitary supervision over localities which are most apt to require such supervision. It is requisite for this object, as well as to enable him to complete the annual returns, that (except where the medical officer of health is himself the Poor-Law medical officer for the whole sanitary area under his superintendence, in which case he will of course possess this information) the guardians should instruct their clerk to copy from the district medical officer's relief lists the new cases which are reported at each meeting of the guardians, and to forward the same promptly and regularly to the medical officer or officers of health within the union. Arrangements should be made for the regular transmission of the copies referred to as early as practicable after each meeting. It is competent to the sanitary authority, whether rural or urban, to pay a reasonable sum to the clerk to the guardians for the supply of this information.

3. The guardians should request the Poor-Law medical officers to give to the medical officer of health (or to the inspector of nuisances, for the information of the medical officer of health) acting within their respective districts, the earliest possible information of cases of dangerous infectious disease under their charge ; as it is evident that unless such information is given as soon as the cases occur, the action of the sanitary authority in regard to the prevention of infection may often fail in its effect.

4. Under the Board's General Order of the 12th February 1879, it is incumbent upon all district and workhouse medical officers appointed since the 28th February 1879, to furnish the medical officer of health with returns of pauper sickness and deaths,

as well as to notify the outbreak of dangerous infectious disease. A similar obligation has been imposed by the Board's Order of the 14th June 1879 upon medical officers of district schools appointed after the 25th June 1879. JOHN LAMBERT, *Secretary.*

Local Government Board, 20th July 1879.

VII.—The DAIRIES, COW-SHEDS, and MILK-SHOPS ORDER of 1879, issued 4th February 1879.

1. *Preliminary.*—This Order may be cited as The Dairies, Cow-Sheds, and Milk-Shops Order of 1879.

2. This Order shall take effect from and immediately after the making thereof.

3. This Order extends to Great Britain only.

4. In this Order—

The Act of 1878 means The Contagious Diseases (Animals) Act, 1878 ;

Other terms have the same meaning as in the Act of 1878.

5. *Registration of Cow-Keepers and others.*—(1.) Every Local Authority shall, with all practicable speed after the making of this Order, open, and shall thenceforth keep, a register for the registration with them under this Order of all persons from time to time carrying on in their district the trade of cow-keepers, dairymen, or purveyors of milk, and shall from time to time revise and correct the register.

(2.) The Local Authority shall give public notice, by advertisement in a newspaper circulating in their district, and, if they think fit, by placards, handbills, or otherwise, of the time at which the register will be opened, and of the mode of registration.

(3.) After the expiration of the time prescribed in this behalf in the advertisement, not being more than two months, and not being less than fourteen days, from the publication of the advertisement, it shall not be lawful for any person to carry on in the district of the Local Authority the trade of a cow-keeper, dairyman, or purveyor of milk, unless he is registered as such under this Order.

6. *Dairies and Cow-Sheds.*—It shall not be lawful for any person following the trade of cow-keeper or dairyman to begin to occupy as a dairy or cow-shed any building not so occupied at the making of this Order, unless and until he first makes provision, to the reasonable satisfaction of the Local Authority, for the lighting, ventilation, cleansing, drainage, and water-supply, of the same, while occupied as a dairy or cow-shed.

7. It shall not be lawful for any person following the trade of cow-keeper or dairyman to occupy as a dairy or cow-shed any building, whether so occupied at the making of this Order or not, if and as long as the lighting, ventilation, cleansing, drainage, and water-supply thereof are not such as are necessary or proper—

(*a*) for the health and good condition of the cattle therein ; and

(*b*) for the cleanliness of milk-vessels used therein for containing milk for sale ; and

(*c*) for the protection of the milk therein against infection and contamination.

8. *Cleansing.*—A Local Authority may, from time to time, make regulations for prescribing and regulating the cleansing of dairies and cow-sheds in the occupation of persons following the trade of cow-keepers or dairymen, and the cleansing of milk-stores, milk-shops, and milk-vessels used for containing milk for sale by such persons.

9. *Contamination of Milk.*—If at any time disease exists among the cattle in a dairy or cow-shed, or other building or place, the milk of a diseased cow therein—

(*a*) shall not be mixed with other milk ; and

(*b*) shall not be sold or used for human food ; and

(*c*) shall not be sold or used for food of swine or other animals, unless and until it has been boiled.

10. It shall not be lawful for any person following the trade of cow-keeper, or dairyman, or purveyor of milk, or being the occupier of a milk-store or milk-shop, to allow any person suffering from a dangerous infectious disorder, or having recently been in contact with a person so suffering, to milk cows, or to handle vessels used for containing milk for sale, or in any way to take part or assist in the conduct of the trade or business of the cow-keeper, dairyman, purveyor of milk, or occupier of the milk-store or milk-shop, as far as regards the production, distribution, or storage of milk, until all danger therefrom of the communication of infection to the milk, or of its contamination, has ceased.

11. It shall not be lawful for a person following the trade of cow-keeper, or dairyman, or purveyor of milk, or being the occupier of a milk-store or milk-shop, to use a milk-store or milk-shop in his occupation, or permit the same to be used, for any purpose incompatible with the proper preservation of the cleanliness of the milk-store or milk-shop, and of the milk-vessels and milk therein, or in any manner likely to cause contamination of the milk therein.

C. L. PEEL.

VIII.—Notice of Infectious Diseases occurring amongst Paupers. (*Author's Form.*)

_____ Sanitary Authority.

Return of District Medical Officer.

Name.	Age.	Residence.	Disease.	Probable Cause.	Steps recommended.

To be folded and forwarded, unsealed, to Sanitary Inspector.

Signed,

District Medical Officer.

Date,

Return of Sanitary Inspector.

Sanitary Condition of Premises.	Action taken.

To be folded and forwarded, unsealed, to Medical Officer of Health.

Signed,

Sanitary Inspector.

Date,

Explanatory Note.—The above form should be printed on paper foolscap size, with the Returns of the District Medical Officer and Sanitary Inspector on one side, and the addresses of the Medical Officer of Health and Sanitary Inspector on the other.

IX.—Clerk's Fortnightly Return to the Medical Officer of Health of all new Cases of Sickness and Deaths appearing from time to time in the Report Books of the several District Medical Officers of the_____ Union. (*Author's Form.*)

*Fortnight ended*_____187

Name.	Age.	Residence.	Disease.	In-door.	Out-door.	Deaths.	Remarks.

Date,

Signed,

Clerk to the Guardians.

Note.—Forms for the births and deaths registered during the week to be forwarded to the medical officer of health can be obtained from Messrs. Knight and Co., 90 Fleet Street, London; Shaw and Sons, Fetter Lane, London; and Farrant and Frost, Merthyr-Tydfil.

X.—Comparison of the Metrical with the Common English Measures, as regards Capacity and Weight, from Tables arranged by Mr. Warren de la Rue, F.R.S.

Measures of Capacity.	In Cubic Inches.	In Cubic Feet = 1728 Cubic Inches.	In Pints 34·65923 Cubic Inches.
Millilitre, or cubic centimetre .	0·061027	0·0000353	0·001761
Centilitre, or 10 cubic centimetres	0·610271	0·0003532	0·017608
Decilitre, or 100 cubic centimetres	6·102705	0·0035317	0·176077
Litre, or cubic decimetre . .	61·027052	0·0353166	1·760773
Decalitre, or centistere . .	610·270515	0·3531658	17·607734
Hectolitre, or decistere . .	6102·705152	3·5316581	176·077341
Kilolitre, or stere, or cubic metre	61027·051519	35·3165807	1760·775314
Myriolitre, or decastere . .	610270·515194	353·1658074	17607·734140

1 cub. in. = 16·3861759 cub. centimetres. 1. cub.ft. = 28·3153119 cub. decimetres.
1 fluid oz. = 28·4 c.c. 1 gallon = 4·543457969 litres. 1 quart = 1·136 litre.

Measures of Weight.	In English Grains.	In Troy Ounces = 480 Grains.	In Avoirdupois Lbs. = 7000 Grains.
Milligramme	0·015432	0·000032	0·0000022
Centigramme	0·154323	0·000322	0·0000220
Decigramme	1·543235	0·003215	0·0002205
Gramme	15·432349	0·032151	0·0022046
Decagramme	154·323488	0·321507	0·0220462
Hectogramme	1543·234880	3·215073	0·2204621
Kilogramme	15432·348800	32·150727	2·2046213
Myriogramme	154323·488000	321·507267	22·0462126

1 Grain = 0·064798950 Gramme. 1 lb. Avd. = 0·45359265 Kilogr.
1 Troy oz. = 31·103496 Gramme. 1 Cwt. = 50·80237689 Kilogr.

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